

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	78	79	80	81	82	83	84	85	86	87	88
Length of alternative route	268,346	283,089	292,138	298,151	282,837	263,997	278,739	287,789	293,801	278,287	288,325
Length of route parallel to existing electric transmission lines	7,925	21,649	47,884	34,159	62,371	18,074	31,798	58,033	44,309	72,520	22,117
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	16,481	15,673	20,823	21,632	15,673	16,481	15,673	20,823	21,632	15,673	26,227
Length of route parallel to pipelines <sup>1</sup>	13,237	13,237	17,599	17,599	17,599	13,811	13,811	18,173	18,173	18,173	11,667
Length of route parallel to apparent property boundaries	51,080	53,768	31,072	28,364	28,364	42,514	45,222	22,507	19,798	19,798	13,405
Total length of route parallel to existing compatible rights-of-way	68,430	84,054	92,723	77,100	99,352	70,014	85,637	94,307	78,683	100,935	54,693
Number of habitable structures within 500 feet of the route centerline <sup>2</sup>	2	2	2	2	2	2	2	2	2	2	2
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	12,038	12,315	12,500	12,704	12,759	11,739	12,016	12,202	12,406	12,461	14,237
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	228,465	248,429	258,762	258,425	251,641	220,182	240,146	250,479	250,142	243,358	249,811
Length of route across agricultural cropland with mobile irrigation systems <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	21,094	19,109	17,548	20,179	15,005	25,326	29,341	21,779	24,411	19,237	21,281
Length of route across potential wetlands	5,433	1,919	2,012	5,526	1,914	5,433	1,919	2,012	5,526	1,914	1,692
Number of stream crossings by the route	13	13	12	12	12	12	12	11	11	11	37
Length of route parallel to streams (within 100 feet)	201	201	0	0	0	201	201	0	0	0	1,788
Length across lakes or ponds (open waters)	83	83	83	83	83	83	83	83	83	83	70
Number of known rare/unique plant locations within the right-of-way	3	3	3	3	3	3	3	3	3	3	0
Length of route through known habitat of endangered or threatened species	10,532	10,532	10,532	10,532	10,532	10,532	10,532	10,532	10,532	10,532	95
Number of recorded cultural resource sites crossed by the route	1	1	1	1	1	1	1	1	1	1	1
Number of recorded cultural resources within 1,000 feet of the route centerline	3	3	3	3	3	3	3	3	3	3	5
Length of route across areas of high archaeological/historical site potential	65,743	68,609	64,701	61,835	64,701	64,408	67,274	63,366	60,500	63,366	90,034
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	1	1	1	1	1	1	1	1	1	1	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	1	1	3	3	3	1	1	3	3	3	0
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	11	11	8	8	8	11	11	8	8	8	8
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	23,119	23,119	23,119	23,119	23,119	23,119	23,119	23,119	23,119	23,119	16,896
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church. <sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	89	90	91	92	93	94	95	96	97	98	99
Length of alternative route	294,337	278,823	287,034	301,777	310,826	316,839	301,325	282,685	297,427	306,477	312,489
Length of route parallel to existing electric transmission lines	8,393	36,604	4,386	18,110	44,345	30,621	58,632	14,535	28,259	54,494	40,770
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	27,036	21,077	20,723	19,914	25,065	25,873	19,914	20,723	19,914	25,065	25,873
Length of route parallel to pipelines <sup>1</sup>	11,667	11,667	4,129	4,129	8,492	8,492	8,492	4,703	4,703	9,066	9,066
Length of route parallel to apparent property boundaries	10,697	10,697	39,332	42,040	19,324	16,616	16,616	30,766	33,474	10,758	8,050
Total length of route parallel to existing compatible rights-of-way	39,069	61,322	57,385	73,008	81,678	66,054	88,307	58,968	74,592	83,261	67,638
Number of habitable structures within 500 feet of the route centerline <sup>2</sup>	2	2	2	2	2	2	2	2	2	2	2
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	14,441	14,496	13,861	14,138	14,323	14,527	14,582	13,562	13,839	14,025	14,229
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	249,474	242,690	242,815	262,780	273,113	272,776	265,992	234,533	254,497	264,830	264,493
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	23,913	18,739	23,811	21,826	20,265	22,896	17,722	28,043	26,058	24,497	27,128
Length of route across potential wetlands	5,207	1,595	5,243	1,729	1,822	5,336	1,725	5,243	1,729	1,822	5,336
Number of stream crossings by the route	37	37	36	36	35	35	35	35	35	34	34
Length of route parallel to streams (within 100 feet)	1,788	1,788	2,115	2,115	1,914	1,914	1,914	2,115	2,115	1,914	1,914
Length across lakes or ponds (open waters)	70	70	70	70	70	70	70	70	70	70	70
Number of known rare/unique plant locations within the right-of-way	0	0	1	1	1	1	1	1	1	1	1
Length of route through known habitat of endangered or threatened species	95	95	95	95	95	95	95	95	95	95	95
Number of recorded cultural resource sites crossed by the route	1	1	0	0	0	0	0	0	0	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	5	5	3	3	3	3	3	3	3	3	3
Length of route across areas of high archaeological/historical site potential	87,168	90,034	88,252	91,118	87,210	84,344	87,210	86,917	89,784	85,876	83,010
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	0	0	1	1	3	3	3	1	1	3	3
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	8	8	12	12	9	9	9	12	12	9	9
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	16,896	16,896	17,145	17,145	17,145	17,145	17,145	17,145	17,145	17,145	17,145
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church. <sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way

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Alternative Route Number	100	101	102	103	104	105	106	107	108	109	110
Length of alternative route	296,975	346,067	344,022	358,764	328,391	347,648	345,603	360,345	329,972	286,132	300,874
Length of route parallel to existing electric transmission lines	68,981	62,703	28,227	41,951	64,257	62,703	28,227	41,951	64,257	4,386	18,110
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	19,914	11,762	20,723	19,914	11,762	11,762	20,723	19,914	11,762	20,723	19,914
Length of route parallel to pipelines <sup>1</sup>	9,066	4,207	4,207	4,207	4,207	4,207	4,207	4,207	4,207	4,129	4,129
Length of route parallel to apparent property boundaries	8,050	58,235	32,813	35,521	32,813	58,235	32,813	35,521	32,813	39,332	42,040
Total length of route parallel to existing compatible rights-of-way	89,890	125,644	74,707	90,331	101,777	125,644	74,707	90,331	101,777	57,385	73,008
Number of habitable structures within 500 feet of the route centerline <sup>1</sup>	2	2	2	2	2	2	2	2	2	2	2
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	14,284	14,239	14,615	14,893	14,225	14,193	14,570	14,847	14,179	13,608	13,885
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	257,709	283,944	286,109	309,073	277,546	285,346	290,510	310,475	278,947	241,941	261,905
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	21,954	40,474	32,726	30,741	32,542	40,899	32,952	30,966	32,767	24,037	22,051
Length of route across potential wetlands	1,725	5,972	6,268	2,754	2,763	5,972	6,268	2,754	2,763	5,243	1,729
Number of stream crossings by the route	34	36	36	36	40	36	36	36	40	36	36
Length of route parallel to streams (within 100 feet)	1,914	2,452	2,374	2,374	2,699	2,452	2,374	2,374	2,699	2,115	2,115
Length across lakes or ponds (open waters)	70	205	70	70	82	205	70	70	82	70	70
Number of known rare/unique plant locations within the right-of-way	1	2	1	1	1	2	1	1	1	1	1
Length of route through known habitat of endangered or threatened species	95	95	95	95	95	95	95	95	95	95	95
Number of recorded cultural resource sites crossed by the route	0	0	0	0	1	0	0	0	1	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	3	3	3	3	4	3	3	3	4	3	3
Length of route across areas of high archaeological/historical site potential	85,876	88,688	80,877	83,743	89,378	88,688	80,877	83,743	89,378	88,252	91,118
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	3	1	1	1	1	1	1	1	1	1	1
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	9	10	9	9	9	10	9	9	9	12	12
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	17,145	27,005	17,145	17,145	20,652	27,005	17,145	17,145	20,652	17,145	17,145
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

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Alternative Route Number	111	112	113	114	115	116	117	118	119	120	121
Length of alternative route	309,924	315,936	300,422	281,782	296,524	305,574	311,587	296,072	288,856	294,868	279,354
Length of route parallel to existing electric transmission lines	44,345	30,621	58,832	14,535	28,259	54,494	40,770	68,981	26,503	12,779	40,990
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	25,065	25,873	19,914	20,723	19,914	25,065	25,873	19,914	25,065	25,873	19,914
Length of route parallel to pipelines <sup>1</sup>	8,492	8,492	8,492	4,703	4,703	9,066	9,066	9,066	11,634	11,634	11,634
Length of route parallel to apparent property boundaries	19,324	16,616	16,616	30,766	33,474	10,758	8,050	8,050	13,405	10,697	10,697
Total length of route parallel to existing compatible rights-of-way	81,678	66,054	88,307	58,968	74,592	83,261	67,638	89,890	57,916	42,293	64,545
Number of habitable structures within 500 feet of the route centerline <sup>2</sup>	2	2	2	2	2	2	2	2	2	2	2
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	14,070	14,274	14,329	13,309	13,586	13,772	13,976	14,031	14,168	14,372	14,427
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	272,238	271,901	265,117	233,658	253,622	263,955	263,618	256,834	252,716	252,379	245,595
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	20,490	23,121	17,948	28,268	26,283	24,722	27,353	22,179	19,630	22,261	17,087
Length of route across potential wetlands	1,822	5,336	1,725	5,243	1,729	1,822	5,336	1,725	1,039	4,553	942
Number of stream crossings by the route	35	35	35	35	35	34	34	34	34	34	34
Length of route parallel to streams (within 100 feet)	1,914	1,914	1,914	2,115	2,115	1,914	1,914	1,914	1,114	1,114	1,114
Length across lakes or ponds (open waters)	70	70	70	70	70	70	70	70	70	70	70
Number of known rare/unique plant locations within the right-of-way	1	1	1	1	1	1	1	1	0	0	0
Length of route through known habitat of endangered or threatened species	95	95	95	95	95	95	95	95	95	95	95
Number of recorded cultural resource sites crossed by the route	0	0	0	0	0	0	0	0	0	1	1
Number of recorded cultural resources within 1,000 feet of the route centerline	3	3	3	3	3	3	3	3	4	4	4
Length of route across areas of high archaeological/historical site potential	87,210	84,344	87,210	86,917	89,764	85,876	83,010	85,876	77,267	74,401	77,267
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	3	3	3	1	1	3	3	3	0	0	0
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	9	9	9	12	12	9	9	9	6	6	6
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	17,145	17,145	17,145	17,145	17,145	17,145	17,145	17,145	16,896	16,896	16,896
Estimated length of right-of-way within foreground visual zone of parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Aerial Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church.

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Alternative Route Number	122	123	124	125	126	127	128	129	130	131	132
Length of alternative route	281,118	295,860	304,910	310,922	295,408	354,098	352,053	366,795	336,422	270,847	285,590
Length of route parallel to existing electric transmission lines	14,535	28,259	54,494	40,770	68,981	62,703	28,227	41,951	64,257	4,386	18,110
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	20,723	19,914	25,065	25,873	19,914	11,762	20,723	19,914	11,762	20,723	19,914
Length of route parallel to pipelines <sup>1</sup>	12,781	12,781	17,144	17,144	17,144	12,285	12,285	12,285	12,285	12,207	12,207
Length of route parallel to apparent property boundaries	32,831	35,539	12,824	10,116	10,116	60,300	34,878	37,587	34,878	41,397	44,105
Total length of route parallel to existing compatible rights-of-way	61,033	76,657	85,326	69,703	91,955	127,709	76,773	92,396	103,842	59,450	75,074
Number of habitable structures within 500 feet of the route centerline <sup>1</sup>	3	3	3	3	3	3	3	3	3	3	3
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	14,504	14,781	14,967	15,170	15,226	15,665	16,042	16,319	15,652	13,877	14,155
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	234,357	254,321	264,654	264,317	257,533	292,410	297,575	317,539	286,012	229,067	249,032
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	26,493	24,508	22,946	25,578	20,404	39,187	31,440	29,454	31,255	22,139	20,154
Length of route across potential wetlands	4,461	946	1,039	4,553	942	5,397	5,693	2,179	2,188	4,461	946
Number of stream crossings by the route	38	38	37	37	37	39	39	39	43	39	39
Length of route parallel to streams (within 100 feet)	1,897	1,897	1,696	1,696	1,696	2,234	2,156	2,156	2,481	1,897	1,897
Length across lakes or ponds (open waters)	70	70	70	70	70	205	70	70	82	70	70
Number of known rare/unique plant locations within the right-of-way	0	0	0	0	0	1	0	0	0	0	0
Length of route through known habitat of endangered or threatened species	95	95	95	95	95	95	95	95	95	95	95
Number of recorded cultural resource sites crossed by the route	0	0	0	0	0	0	0	0	1	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	2	2	2	2	2	2	2	2	3	2	2
Length of route across areas of high archaeological/historical site potential	95,655	98,521	94,613	91,747	94,613	97,425	89,614	92,480	98,115	93,158	96,024
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	1	1	3	3	3	1	1	1	1	1	1
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	9	9	6	6	6	7	6	6	6	9	9
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	18,462	18,462	18,462	18,462	18,462	28,322	18,462	18,462	21,970	18,462	18,462
Estimated length of right-of-way within foreground visual zone of parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Aeronautics and Space Administration (NASA) Landsat 7 satellite imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church. <sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	133	134	135	136	137	138	139	140	141	142	143
Length of alternative route	294,639	300,652	285,138	340,151	354,893	363,943	369,955	354,441	335,801	350,544	359,593
Length of route parallel to existing electric transmission lines	44,345	30,621	58,832	30,554	44,278	70,513	56,789	85,000	40,703	54,427	80,662
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	25,065	25,873	19,914	37,854	37,045	42,195	43,004	37,045	37,854	37,045	42,195
Length of route parallel to pipelines <sup>1</sup>	16,570	16,570	16,570	9,263	9,263	13,625	13,625	13,625	9,837	9,837	14,199
Length of route parallel to apparent property boundaries	21,389	18,681	18,681	48,476	51,184	28,468	25,760	25,760	39,910	42,619	19,903
Total length of route parallel to existing compatible rights-of-way	83,743	68,120	90,372	109,828	125,451	134,121	118,497	140,750	111,411	127,035	135,704
Number of habitable structures within 500 feet of the route centerline <sup>1</sup>	3	3	3	2	2	2	2	2	2	2	2
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	14,340	14,544	14,599	16,718	16,995	17,190	17,384	17,439	16,419	16,696	16,882
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	259,364	259,028	252,243	287,658	307,623	317,955	317,619	310,634	279,375	299,340	309,673
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	18,593	21,224	16,050	28,566	26,580	25,019	27,650	22,477	32,797	30,812	29,251
Length of route across potential wetlands	1,039	4,553	942	5,927	2,413	2,506	6,020	2,408	5,927	2,419	2,506
Number of stream crossings by the route	38	38	38	37	37	36	36	36	36	36	35
Length of route parallel to streams (within 100 feet)	1,696	1,696	1,696	3,304	3,304	3,103	3,103	3,103	3,304	3,304	3,103
Length across lakes or ponds (open waters)	70	70	70	49	49	49	49	49	49	49	49
Number of known rare/unique plant locations within the right-of-way	0	0	0	1	1	1	1	1	1	1	1
Length of route through known habitat of endangered or threatened species	95	95	95	50	50	50	50	50	50	50	50
Number of recorded cultural resource sites crossed by the route	0	0	0	0	0	0	0	0	0	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	2	2	2	4	4	4	4	4	4	4	4
Length of route across areas of high archaeological/historical site potential	92,116	89,250	92,116	109,489	112,355	108,447	105,581	108,447	108,154	111,020	107,112
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	3	3	3	1	1	3	3	3	1	1	3
Number of U.S. or State Highway crossings by the route	3	3	3	2	2	2	2	2	2	2	2
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	6	6	6	12	12	9	9	9	12	12	9
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	18,462	18,462	18,462	14,471	14,471	14,471	14,471	14,471	14,471	14,471	14,471
Estimated length of right-of-way within foreground visual zone of parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Aerial Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church. <sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	144	145	146	147	148	149	150	151	152	153	154
Length of alternative route	385,606	350,091	399,184	397,138	411,061	381,508	400,765	398,719	413,462	383,089	339,248
Length of route parallel to existing electric transmission lines	66,938	95,149	88,871	54,395	68,119	90,426	88,671	54,395	68,119	90,426	30,554
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	43,004	37,045	28,893	37,854	37,045	28,893	28,893	37,854	37,045	28,893	37,854
Length of route parallel to pipelines <sup>1</sup>	14,199	14,199	9,340	9,340	9,340	9,340	9,340	9,340	9,340	9,340	9,263
Length of route parallel to apparent property boundaries	17,195	17,195	67,379	41,957	44,666	41,957	67,379	41,957	44,666	41,957	48,476
Total length of route parallel to existing compatible rights-of-way	120,081	142,333	178,087	127,150	142,774	154,220	178,087	127,150	142,774	154,220	109,828
Number of habitable structures within 500 feet of the route centerline <sup>2</sup>	2	2	2	2	2	2	2	2	2	2	2
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	17,085	17,141	17,096	17,472	17,750	17,082	17,050	17,426	17,704	17,036	16,465
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	309,336	302,552	328,787	333,951	353,916	322,388	330,188	335,353	355,317	323,790	286,783
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	31,882	26,708	45,228	37,481	35,495	37,296	45,454	37,706	35,721	37,521	28,791
Length of route across potential wetlands	6,020	2,408	6,655	6,952	3,437	3,447	6,655	6,952	3,437	3,447	5,927
Number of stream crossings by the route	35	35	37	37	37	41	37	37	37	41	37
Length of route parallel to streams (within 100 feet)	3,103	3,103	3,641	3,563	3,563	3,888	3,641	3,563	3,563	3,888	3,304
Length across lakes or ponds (open waters)	49	49	184	49	49	61	184	49	49	61	49
Number of known rare/unique plant locations within the right-of-way	1	1	2	1	1	1	2	1	1	1	1
Length of route through known habitat of endangered or threatened species	50	50	50	50	50	50	50	50	50	50	50
Number of recorded cultural resource sites crossed by the route	0	0	0	0	0	0	0	0	0	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	4	4	4	4	4	5	4	4	4	5	4
Length of route across areas of high archaeological/historical site potential	104,246	107,112	109,925	102,113	104,980	110,614	109,925	102,113	104,980	110,614	109,489
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	3	3	1	1	1	1	1	1	1	1	1
Number of U.S. or State Highway crossings by the route	2	2	2	2	2	2	2	2	2	2	2
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	9	9	10	9	9	9	10	9	9	9	12
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	14,471	14,471	24,331	14,471	14,471	17,979	24,331	14,471	14,471	17,979	14,471
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church. <sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	155	156	157	158	159	160	161	162	163	164	165
Length of alternative route	353,990	363,040	369,053	353,538	334,898	349,641	358,690	364,703	349,189	341,972	347,985
Length of route parallel to existing electric transmission lines	44,278	70,513	56,789	85,000	40,703	54,427	80,662	66,938	95,149	52,671	38,947
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	37,045	42,195	43,004	37,045	37,654	37,045	42,195	43,004	37,045	42,195	43,004
Length of route parallel to pipelines <sup>1</sup>	9,263	13,625	13,625	13,625	9,837	9,837	14,199	14,199	14,199	16,767	16,767
Length of route parallel to apparent property boundaries	51,184	28,468	25,760	25,760	39,910	42,619	19,903	17,195	17,195	22,549	19,841
Total length of route parallel to existing compatible rights-of-way	125,451	134,121	118,497	140,750	111,411	127,035	135,704	120,081	142,333	110,359	94,736
Number of habitable structures within 500 feet of the route centerline <sup>1</sup>	2	2	2	2	2	2	2	2	2	2	2
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	16,742	16,927	17,131	17,186	16,166	16,443	16,629	16,832	16,888	17,025	17,229
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	306,748	317,080	316,744	309,959	278,500	298,465	308,798	308,461	301,677	297,558	297,222
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	26,806	25,244	27,876	22,702	33,023	31,038	29,476	32,107	26,934	24,384	27,015
Length of route across potential wetlands	2,413	2,506	6,020	2,408	5,927	2,413	2,506	6,020	2,408	1,723	5,237
Number of stream crossings by the route	37	36	36	36	36	36	35	35	35	35	35
Length of route parallel to streams (within 100 feet)	3,304	3,103	3,103	3,103	3,304	3,304	3,103	3,103	3,103	2,303	2,303
Length across lakes or ponds (open waters)	49	49	49	49	49	49	49	49	49	49	49
Number of known rare/unique plant locations within the right-of-way	1	1	1	1	1	1	1	1	1	0	0
Length of route through known habitat of endangered or threatened species	50	50	50	50	50	50	50	50	50	50	50
Number of recorded cultural resource sites crossed by the route	0	0	0	0	0	0	0	0	0	1	1
Number of recorded cultural resources within 1,000 feet of the route centerline	4	4	4	4	4	4	4	4	4	5	5
Length of route across areas of high archaeological/historical site potential	112,355	108,447	105,581	108,447	108,154	111,020	107,112	104,246	107,112	98,503	95,637
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	1	3	3	3	1	1	3	3	3	0	0
Number of U.S. or State Highway crossings by the route	2	2	2	2	2	2	2	2	2	2	2
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	12	9	9	9	12	12	9	9	9	6	6
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	14,471	14,471	14,471	14,471	14,471	14,471	14,471	14,471	14,471	14,222	14,222
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church.

<sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way.

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	166	167	168	169	170	171	172	173	174	175	176
Length of alternative route	332,471	334,234	348,976	358,026	364,039	348,524	407,215	405,169	419,912	389,539	323,964
Length of route parallel to existing electric transmission lines	67,158	40,703	54,427	80,662	66,938	95,149	88,871	54,395	68,119	90,426	30,554
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	37,045	37,854	37,045	42,195	43,004	37,045	28,893	37,854	37,045	28,893	37,854
Length of route parallel to pipelines <sup>1</sup>	16,767	17,915	17,915	22,277	22,277	22,277	17,418	17,418	17,418	17,418	17,341
Length of route parallel to apparent property boundaries	19,841	41,976	44,684	21,968	19,260	19,260	69,444	44,023	46,731	44,023	50,541
Total length of route parallel to existing compatible rights-of-way	116,988	113,477	129,100	137,770	122,146	144,398	180,152	129,216	144,839	156,285	111,893
Number of habitable structures within 500 feet of the route centerline <sup>1</sup>	2	3	3	3	3	3	3	3	3	3	3
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	17,284	17,361	17,638	17,824	18,027	18,083	18,522	18,899	19,176	18,508	16,734
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	290,437	279,199	299,164	309,497	309,160	302,376	337,253	342,417	362,382	330,854	273,910
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	21,842	31,247	29,262	27,701	30,332	25,158	43,942	36,194	34,209	36,010	26,893
Length of route across potential wetlands	1,625	5,144	1,630	1,729	5,237	1,625	6,080	6,377	2,863	2,872	5,144
Number of stream crossings by the route	35	39	39	38	38	38	40	40	40	44	40
Length of route parallel to streams (within 100 feet)	2,303	3,086	3,086	2,885	2,885	2,885	3,423	3,345	3,345	3,670	3,086
Length across lakes or ponds (open waters)	49	49	49	49	49	49	184	49	49	61	49
Number of known rare/unique plant locations within the right-of-way	0	0	0	0	0	0	1	0	0	0	0
Length of route through known habitat of endangered or threatened species	50	50	50	50	50	50	50	50	50	50	50
Number of recorded cultural resource sites crossed by the route	1	0	0	0	0	0	0	0	0	1	0
Number of recorded cultural resources within 1,000 feet of the route centerline	5	3	3	3	3	3	3	3	3	4	3
Length of route across areas of high archaeological/historical site potential	98,503	116,891	119,757	115,850	112,863	115,850	118,662	110,851	113,717	119,351	114,395
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	0	1	1	3	3	3	1	1	1	1	1
Number of U.S. or State Highway crossings by the route	2	2	2	2	2	2	2	2	2	2	2
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	6	9	9	6	6	6	7	6	6	6	9
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	14,222	15,788	15,788	15,788	15,788	15,788	25,645	15,788	15,788	19,296	15,788
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church. <sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	177	178	179	180	181	182	183	184	185	186	187
Length of alternative route	338,706	347,758	353,769	338,254	319,437	325,449	309,935	292,744	298,757	283,243	291,454
Length of route parallel to existing electric transmission lines	44,278	70,513	56,789	85,000	48,285	34,561	62,772	22,117	8,393	36,604	4,386
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	37,045	42,195	43,004	37,045	31,621	32,429	26,470	26,033	26,842	20,883	20,529
Length of route parallel to pipelines <sup>1</sup>	17,341	21,703	21,703	21,703	6,534	6,534	6,534	11,667	11,667	11,667	4,129
Length of route parallel to apparent property boundaries	53,250	30,534	27,826	27,826	22,549	19,841	19,841	13,211	10,502	10,502	39,138
Total length of route parallel to existing compatible rights-of-way	127,517	136,186	120,563	142,815	95,399	79,775	102,028	54,499	38,875	61,128	57,191
Number of habitable structures within 500 feet of the route centerline <sup>1</sup>	3	3	3	3	2	2	2	37	37	37	37
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	17,012	17,197	17,401	17,456	16,105	16,309	16,364	14,368	14,572	14,628	13,992
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	293,874	304,207	303,870	297,086	278,757	278,421	271,636	253,061	252,724	245,940	246,066
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	24,908	23,347	25,978	20,804	20,916	23,548	18,374	22,328	24,959	19,786	24,858
Length of route across potential wetlands	1,630	1,723	5,237	1,625	2,376	5,880	2,279	1,634	5,148	1,537	5,185
Number of stream crossings by the route	40	39	39	39	32	32	32	41	41	41	40
Length of route parallel to streams (within 100 feet)	3,066	2,885	2,885	2,885	2,977	2,977	2,977	1,788	1,788	1,788	2,115
Length across lakes or ponds (open waters)	49	49	49	49	49	49	49	120	120	120	120
Number of known rare/unique plant locations within the right-of-way	0	0	0	0	0	0	0	0	0	0	1
Length of route through known habitat of endangered or threatened species	50	50	50	50	50	50	50	95	95	95	95
Number of recorded cultural resource sites crossed by the route	0	0	0	0	1	1	1	1	1	1	0
Number of recorded cultural resources within 1,000 feet of the route centerline	3	3	3	3	6	6	6	3	3	3	1
Length of route across areas of high archaeological/historical site potential	117,261	113,353	110,487	113,353	100,595	97,729	100,595	91,073	88,207	91,073	89,291
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	1	3	3	3	0	0	0	0	0	0	1
Number of U.S. or State Highway crossings by the route	2	2	2	2	2	2	2	3	3	3	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	9	6	6	6	8	8	8	12	12	12	16
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	15,788	15,786	15,786	15,788	14,222	14,222	14,222	16,896	16,896	16,896	17,145
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church. <sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	188	189	190	191	192	193	194	195	196	197	198
Length of alternative route	306,196	315,246	321,259	305,744	287,104	301,847	310,896	316,909	301,395	350,487	348,442
Length of route parallel to existing electric transmission lines	18,110	44,345	30,621	58,832	14,535	28,259	54,494	40,770	68,981	62,703	28,227
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	19,720	24,871	25,679	19,720	20,529	19,720	24,871	25,679	19,720	11,568	20,529
Length of route parallel to pipelines <sup>1</sup>	4,129	8,492	8,492	8,492	4,703	4,703	9,066	9,066	9,066	4,207	4,207
Length of route parallel to apparent property boundaries	41,846	19,130	16,422	16,422	30,572	33,280	10,564	7,856	7,856	58,041	32,619
Total length of route parallel to existing compatible rights-of-way	72,814	81,484	65,860	88,113	58,774	74,398	83,067	67,444	89,696	125,450	74,513
Number of habitable structures within 500 feet of the route centerline <sup>1</sup>	37	37	37	37	37	37	37	37	37	37	37
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	14,269	14,455	14,658	14,714	13,693	13,971	14,156	14,360	14,415	14,370	14,747
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	266,030	276,363	276,026	269,242	237,783	257,747	268,080	267,743	260,959	287,195	292,359
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	22,873	21,312	23,943	18,769	29,090	27,105	25,543	28,175	23,001	41,521	33,773
Length of route across potential wetlands	1,671	1,764	5,278	1,667	5,185	1,671	1,764	5,278	1,667	5,913	6,210
Number of stream crossings by the route	40	39	39	39	39	39	38	38	38	40	40
Length of route parallel to streams (within 100 feet)	2,115	1,914	1,914	1,914	2,115	2,115	1,914	1,914	1,914	2,452	2,374
Length across lakes or ponds (open waters)	120	120	120	120	120	120	120	120	120	255	120
Number of known rare/unique plant locations within the right-of-way	1	1	1	1	1	1	1	1	1	2	1
Length of route through known habitat of endangered or threatened species	95	95	95	95	95	95	95	95	95	95	95
Number of recorded cultural resource sites crossed by the route	0	0	0	0	0	0	0	0	0	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	1	1	1	1	1	1	1	1	1	1	1
Length of route across areas of high archaeological/historical site potential	92,157	88,249	85,383	88,249	87,956	90,822	86,914	84,048	86,914	89,727	81,915
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	1	3	3	3	3	1	3	3	3	3	1
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	16	13	13	13	16	16	13	13	13	14	13
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	17,145	17,145	17,145	17,145	17,145	17,145	17,145	17,145	17,145	27,005	17,145
Estimated length of right-of-way within foreground visual zone of parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church. <sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	199	200	201	202	203	204	205	206	207	208	209
Length of alternative route	963,184	332,811	352,068	350,023	364,765	334,392	290,551	305,294	314,343	320,356	304,842
Length of route parallel to existing electric transmission lines	41,951	64,257	62,703	28,227	41,951	64,257	4,386	18,110	44,345	30,621	58,832
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	19,720	11,568	11,568	20,529	19,720	11,568	20,529	19,720	24,871	25,679	19,720
Length of route parallel to pipelines <sup>1</sup>	4,207	4,207	4,207	4,207	4,207	4,207	4,129	4,129	8,492	8,492	8,492
Length of route parallel to apparent property boundaries	35,327	32,619	58,041	32,619	35,327	32,619	39,138	41,846	19,130	16,422	16,422
Total length of route parallel to existing compatible rights-of-way	90,137	101,583	125,450	74,513	90,137	101,583	57,191	72,814	81,484	65,860	88,113
Number of habitable structures within 500 feet of the route centerline <sup>2</sup>	37	37	37	37	37	37	37	37	37	37	37
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	15,024	14,356	14,324	14,701	14,978	14,311	13,739	14,016	14,202	14,405	14,461
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	312,324	280,796	288,596	293,760	313,725	282,197	245,191	265,155	275,488	275,151	268,367
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	31,788	33,589	41,746	33,998	32,013	33,814	25,083	23,098	21,537	24,168	18,994
Length of route across potential wetlands	2,696	2,705	5,913	6,210	2,696	2,705	5,185	1,671	1,764	5,278	1,667
Number of stream crossings by the route	40	44	40	40	40	44	40	40	39	39	39
Length of route parallel to streams (within 100 feet)	2,374	2,699	2,452	2,374	2,374	2,699	2,115	2,115	1,914	1,914	1,914
Length across lakes or ponds (open waters)	120	132	255	120	120	132	120	120	120	120	120
Number of known rare/unique plant locations within the right-of-way	1	1	2	1	1	1	1	1	1	1	1
Length of route through known habitat of endangered or threatened species	95	95	95	95	95	95	95	95	95	95	95
Number of recorded cultural resource sites crossed by the route	0	1	0	0	0	1	0	0	0	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	1	2	1	1	1	2	1	1	1	1	1
Length of route across areas of high archaeological/historical site potential	84,782	90,416	89,727	81,915	84,782	90,416	89,291	92,157	88,249	85,383	88,249
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	1	1	1	1	1	1	1	1	3	3	3
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	13	13	14	13	13	13	16	16	13	13	13
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	17,145	20,652	27,005	17,145	17,145	20,652	17,145	17,145	17,145	17,145	17,145
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church. <sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	210	211	212	213	214	215	216	217	218	219	220
Length of alternative route	286,202	300,944	309,994	316,006	300,492	293,276	299,288	283,774	285,537	300,280	309,329
Length of route parallel to existing electric transmission lines	14,535	28,259	54,494	40,770	68,981	26,503	12,779	40,990	14,535	28,259	54,494
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	20,529	19,720	24,871	25,679	19,720	24,871	25,679	19,720	20,529	19,720	24,871
Length of route parallel to pipelines <sup>1</sup>	4,703	4,703	9,066	9,066	9,066	11,634	11,634	11,634	12,781	12,781	17,144
Length of route parallel to apparent property boundaries	30,572	33,280	10,564	7,856	7,856	13,211	10,502	10,502	32,637	35,345	12,630
Total length of route parallel to existing compatible rights-of-way	58,774	74,398	83,067	67,444	89,696	57,722	42,099	64,351	60,839	76,463	85,132
Number of habitable structures within 500 feet of the route centerline <sup>1</sup>	37	37	37	37	37	37	37	37	38	38	38
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	13,440	13,718	13,903	14,107	14,162	14,299	14,503	14,558	14,635	14,913	15,098
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	236,908	256,872	267,205	266,868	260,084	255,966	255,629	248,845	237,607	257,572	267,904
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	29,315	27,330	25,769	28,400	23,226	20,677	23,308	18,134	27,540	25,554	23,993
Length of route across potential wetlands	5,185	1,671	1,784	5,278	1,667	981	4,495	884	4,402	888	981
Number of stream crossings by the route	39	39	36	38	38	38	38	38	42	42	41
Length of route parallel to streams (within 100 feet)	2,115	2,115	1,914	1,914	1,914	1,114	1,114	1,114	1,897	1,897	1,896
Length across lakes or ponds (open waters)	120	120	120	120	120	120	120	120	120	120	120
Number of known rare/unique plant locations within the right-of-way	1	1	1	1	1	0	0	0	0	0	0
Length of route through known habitat of endangered or threatened species	95	95	95	95	95	95	95	95	95	95	95
Number of recorded cultural resource sites crossed by the route	0	0	0	0	0	1	1	1	0	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	1	1	1	1	1	2	2	2	0	0	0
Length of route across areas of high archaeological/historical site potential	87,956	90,822	86,914	84,048	86,914	78,305	75,439	78,305	96,693	99,559	95,652
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	1	1	3	3	3	0	0	0	1	1	3
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	16	16	13	13	13	10	10	10	13	13	10
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	17,145	17,145	17,145	17,145	17,145	16,896	16,896	16,896	18,462	18,462	18,462
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church. <sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	221	222	223	224	225	226	227	228	229	230	231
Length of alternative route	315,342	299,828	358,518	356,473	371,215	340,842	275,267	290,010	299,059	305,072	289,558
Length of route parallel to existing electric transmission lines	40,770	68,981	62,703	28,227	41,951	64,257	4,386	18,110	44,345	30,621	58,832
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	25,679	19,720	11,568	20,529	19,720	11,568	20,529	19,720	24,871	25,679	19,720
Length of route parallel to pipelines <sup>1</sup>	17,144	17,144	12,285	12,285	12,285	12,285	12,207	12,207	16,570	16,570	16,570
Length of route parallel to apparent property boundaries	9,921	9,921	60,106	34,684	37,392	34,684	41,203	43,911	21,195	18,487	18,487
Total length of route parallel to existing compatible rights-of-way	69,509	91,761	127,515	76,579	92,202	103,648	59,256	74,880	83,549	67,926	90,178
Number of habitable structures within 500 feet of the route centerline <sup>2</sup>	38	38	38	38	38	38	38	38	38	38	38
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	15,302	15,357	15,796	16,173	16,450	15,783	14,009	14,286	14,471	14,675	14,730
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	267,568	260,783	295,661	300,825	320,790	289,262	232,317	252,282	262,615	262,278	255,494
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	26,624	21,451	40,234	32,486	30,501	32,302	23,186	21,201	19,639	22,271	17,097
Length of route across potential wetlands	4,495	884	5,338	5,635	2,121	2,130	4,402	888	981	4,495	884
Number of stream crossings by the route	41	41	43	43	43	47	43	43	42	42	42
Length of route parallel to streams (within 100 feet)	1,696	1,696	2,234	2,156	2,156	2,481	1,897	1,897	1,696	1,696	1,696
Length across lakes or ponds (open waters)	120	120	255	120	120	132	120	120	120	120	120
Number of known rare/unique plant locations within the right-of-way	0	0	1	0	0	0	0	0	0	0	0
Length of route through known habitat of endangered or threatened species	95	95	95	95	95	95	95	95	95	95	95
Number of recorded cultural resource sites crossed by the route	0	0	0	0	0	1	0	0	0	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	0	0	0	0	0	1	0	0	0	0	0
Length of route across areas of high archaeological/historical site potential <sup>4</sup>	92,785	95,652	98,464	90,653	93,519	99,153	94,197	97,063	93,155	90,289	93,155
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	3	3	1	1	1	1	1	1	3	3	3
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	10	10	11	10	10	10	13	13	10	10	10
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	18,462	18,462	28,322	18,462	18,462	21,970	18,462	18,462	18,462	18,462	18,462
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. <sup>2</sup>Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>3</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church. <sup>4</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	232	233	234	235	236	237	238	239	240	241	242
Length of alternative route	344,570	359,313	368,362	374,375	358,861	340,221	354,963	364,013	370,025	354,511	403,603
Length of route parallel to existing electric transmission lines	30,554	44,278	70,513	56,789	85,000	40,703	54,427	80,662	66,938	95,149	88,871
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	37,660	36,851	42,001	42,810	36,851	37,660	36,851	42,001	42,810	36,851	28,699
Length of route parallel to pipelines <sup>1</sup>	9,263	9,263	13,625	13,625	13,625	9,837	9,837	14,199	14,199	14,199	9,340
Length of route parallel to apparent property boundaries	48,282	50,990	28,274	25,566	25,566	39,716	42,425	19,709	17,001	17,001	67,185
Total length of route parallel to existing compatible rights-of-way	109,634	125,257	133,927	118,303	140,556	111,217	126,841	135,510	119,887	142,139	177,893
Number of habitable structures within 500 feet of the route centerline <sup>2</sup>	37	37	37	37	37	37	37	37	37	37	37
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	16,549	17,126	17,312	17,515	17,571	16,550	16,828	17,013	17,217	17,272	17,227
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	290,908	310,873	321,206	320,869	314,085	282,626	302,590	312,923	312,586	305,802	332,037
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	29,613	27,627	26,066	28,697	23,523	33,844	31,859	30,295	32,929	27,755	46,275
Length of route across potential wetlands	5,869	2,354	2,447	5,962	2,350	5,869	2,354	2,447	5,962	2,350	6,597
Number of stream crossings by the route	41	41	40	40	40	40	40	39	39	39	41
Length of route parallel to streams (within 100 feet)	3,304	3,304	3,103	3,103	3,103	3,304	3,304	3,103	3,103	3,103	3,641
Length across lakes or ponds (open waters)	99	99	99	99	99	99	99	99	99	99	234
Number of known rare/unique plant locations within the right-of-way	1	1	1	1	1	1	1	1	1	1	2
Length of route through known habitat of endangered or threatened species	50	50	50	50	50	50	50	50	50	50	50
Number of recorded cultural resource sites crossed by the route	0	0	0	0	0	0	0	0	0	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	2	2	2	2	2	2	2	2	2	2	2
Length of route across areas of high archaeological/historical site potential	110,527	113,393	109,486	106,619	109,486	109,193	112,059	108,151	105,285	108,151	110,963
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	1	1	3	3	3	1	1	3	3	3	1
Number of U.S. or State Highway crossings by the route	2	2	2	2	2	2	2	2	2	2	2
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	16	16	13	13	13	16	16	13	13	13	14
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	14,471	14,471	14,471	14,471	14,471	14,471	14,471	14,471	14,471	14,471	24,331
Estimated length of right-of-way within foreground visual zone of parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0

E-22

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church.

<sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way.

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	243	244	245	246	247	248	249	250	251	252	253
Length of alternative route	401,558	416,301	385,928	405,184	403,139	417,881	387,508	343,668	358,410	367,450	373,472
Length of route parallel to existing electric transmission lines	54,395	68,119	90,426	88,871	54,395	68,119	90,426	30,554	44,278	70,513	56,789
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	37,660	36,851	28,699	28,699	37,660	36,851	28,699	37,660	36,851	42,001	42,810
Length of route parallel to pipelines <sup>1</sup>	9,340	9,340	9,340	9,340	9,340	9,340	9,340	9,263	9,263	13,625	13,625
Length of route parallel to apparent property boundaries	41,763	44,472	41,763	67,185	41,763	44,472	41,763	48,282	50,990	28,274	25,566
Total length of route parallel to existing compatible rights-of-way	126,956	142,580	154,026	177,893	126,956	142,580	154,026	109,634	125,257	133,927	118,303
Number of habitable structures within 500 feet of the route centerline <sup>1</sup>	37	37	37	37	37	37	37	37	37	37	37
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	17,604	17,881	17,213	17,181	17,558	17,835	17,168	16,596	16,873	17,059	17,262
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland pasture	337,202	357,166	325,639	333,439	338,603	358,568	327,040	290,033	309,998	320,331	319,994
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	38,527	36,542	38,343	46,500	38,753	36,768	38,568	29,838	27,853	26,291	28,923
Length of route across potential wetlands	6,893	3,379	3,388	6,597	6,893	3,379	3,388	5,869	2,354	2,447	5,962
Number of stream crossings by the route	41	41	45	41	41	41	45	41	41	40	40
Length of route parallel to streams (within 100 feet)	3,563	3,563	3,888	3,641	3,563	3,563	3,888	3,304	3,304	3,103	3,103
Length across lakes or ponds (open waters)	99	99	111	234	99	99	111	99	99	99	99
Number of known rare/unique plant locations within the right-of-way	1	1	1	2	1	1	1	1	1	1	1
Length of route through known habitat of endangered or threatened species	50	50	50	50	50	50	50	50	50	50	50
Number of recorded cultural resource sites crossed by the route	0	0	1	0	0	0	1	0	0	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	2	2	3	2	2	2	3	2	2	2	2
Length of route across areas of high archaeological/historical site potential	103,152	106,018	111,653	110,963	103,152	106,018	111,653	110,527	113,393	109,486	106,619
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	1	1	1	1	1	1	1	1	1	3	3
Number of U.S. or State Highway crossings by the route	2	2	2	2	2	2	2	2	2	2	2
Number of Farm to Market (F.M.) county roads or other street crossings by the route	13	13	13	14	13	13	13	18	16	13	13
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	14,471	14,471	17,979	24,331	14,471	14,471	17,979	14,471	14,471	14,471	14,471
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Aerial Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church.

<sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way.

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	254	255	256	257	258	259	260	261	262	263	264
Length of alternative route	357,958	339,318	354,061	363,110	369,123	353,608	346,392	352,405	336,890	338,654	353,396
Length of route parallel to existing electric transmission lines	85,000	40,703	54,427	80,662	66,936	95,149	52,671	38,947	67,158	40,703	54,427
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	36,851	37,660	36,851	42,001	42,810	36,851	42,001	42,810	36,851	37,660	36,851
Length of route parallel to pipelines*	13,625	9,837	9,837	14,199	14,199	14,199	16,767	16,767	16,767	17,915	17,915
Length of route parallel to apparent property boundaries	25,566	39,716	42,425	19,709	17,001	17,001	22,355	19,647	19,647	41,782	44,490
Total length of route parallel to existing compatible rights-of-way	140,556	111,217	126,841	135,510	119,887	142,139	110,165	94,542	116,794	113,283	128,906
Number of habitable structures within 500 feet of the route centerline <sup>1</sup>	37	37	37	37	37	37	37	37	37	37	38
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	17,318	16,297	16,575	16,760	16,964	17,019	17,156	17,360	17,415	17,492	17,770
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	313,210	281,751	301,715	312,048	311,711	304,927	300,808	300,472	293,687	282,450	302,414
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	23,749	34,070	32,084	30,523	33,154	27,981	25,431	28,062	22,886	32,294	30,909
Length of route across potential wetlands	2,350	5,869	2,354	2,447	5,962	2,350	1,664	5,179	1,567	5,086	1,571
Number of stream crossings by the route	40	40	40	39	39	39	39	39	39	39	43
Length of route parallel to streams (within 100 feet)	3,103	3,304	3,304	3,103	3,103	3,103	2,303	2,303	2,303	3,086	3,086
Length across lakes or ponds (open waters)	99	99	99	99	99	99	99	99	99	99	99
Number of known rare/unique plant locations within the right-of-way	1	1	1	1	1	1	0	0	0	0	0
Length of route through known habitat of endangered or threatened species	50	50	50	50	50	50	50	50	50	50	50
Number of recorded cultural resource sites crossed by the route	0	0	0	0	0	0	1	1	1	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	2	2	2	2	2	2	3	3	3	1	1
Length of route across areas of high archaeological/historical site potential	109,486	109,193	112,059	108,151	105,285	108,151	99,542	96,676	99,542	117,930	120,796
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	3	1	1	3	3	3	0	0	0	1	1
Number of U.S. or State Highway crossings by the route	2	2	2	2	2	2	2	2	2	2	2
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	13	16	16	13	13	13	10	10	10	13	13
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	14,471	14,471	14,471	14,471	14,471	14,471	14,222	14,222	14,222	15,788	15,788
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church. <sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	265	266	267	268	269	270	271	272	273	274	275
Length of alternative route	362,446	368,458	352,944	411,634	409,589	424,331	393,959	328,384	343,126	352,176	358,188
Length of route parallel to existing electric transmission lines	80,662	66,938	95,149	88,871	54,395	66,119	90,426	30,554	44,278	70,513	56,789
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	42,001	42,810	36,851	28,699	37,660	36,851	28,699	37,660	36,851	42,001	42,810
Length of route parallel to pipelines <sup>1</sup>	22,277	22,277	22,277	17,418	17,418	17,418	17,418	17,341	17,341	21,703	21,703
Length of route parallel to apparent property boundaries	21,774	19,066	19,066	69,250	43,829	46,537	43,829	50,347	53,056	30,340	27,632
Total length of route parallel to existing compatible rights-of-way	137,576	121,952	144,204	179,958	129,022	144,645	156,091	111,699	127,323	135,992	120,369
Number of habitable structures within 500 feet of the route centerline <sup>2</sup>	38	38	38	38	38	38	38	38	38	38	38
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	17,955	18,159	18,214	18,653	19,030	19,307	18,640	16,666	17,143	17,328	17,532
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	312,747	312,410	305,626	340,503	345,668	365,632	334,105	277,160	297,125	307,457	307,121
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	28,747	31,379	26,205	44,988	37,241	35,256	37,056	27,940	25,955	24,394	27,025
Length of route across potential wetlands	1,664	5,179	1,567	6,022	6,319	2,804	2,814	5,086	1,571	1,664	5,179
Number of stream crossings by the route	42	42	42	44	44	44	45	44	44	43	43
Length of route parallel to streams (within 100 feet)	2,885	2,885	2,885	3,423	3,345	3,345	3,670	3,086	3,086	2,885	2,885
Length across lakes or ponds (open waters)	99	99	99	234	99	99	111	99	99	99	99
Number of known rare/unique plant locations within the right-of-way	0	0	0	1	0	0	0	0	0	0	0
Length of route through known habitat of endangered or threatened species	50	50	50	50	50	50	50	50	50	50	50
Number of recorded cultural resource sites crossed by the route	0	0	0	0	0	0	1	0	0	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	1	1	1	1	1	1	2	1	1	1	1
Length of route across areas of high archaeological/historical site potential	116,888	114,022	116,888	119,700	111,889	114,755	120,390	115,433	118,299	114,392	111,525
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	3	3	3	1	1	1	1	1	1	3	3
Number of U.S. or State Highway crossings by the route	2	2	2	2	2	2	2	2	2	2	2
Number of Farm to Market (FM) county roads or other street crossings by the route	10	10	10	11	10	10	10	13	13	10	10
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	15,788	15,788	15,788	25,648	15,788	15,788	19,296	15,788	15,788	15,788	15,788
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church. <sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	276	277	278	279	280	281	282	283	284	285	286
Length of alternative route	342,674	323,857	329,869	314,355	267,199	273,212	257,698	259,461	274,203	283,253	289,266
Length of route parallel to existing electric transmission lines	85,000	48,285	34,561	62,772	22,117	8,393	36,604	10,149	23,873	50,108	36,384
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	36,851	31,427	32,235	26,276	20,629	21,438	15,479	16,287	15,479	20,629	21,438
Length of route parallel to pipelines <sup>1</sup>	21,703	6,534	6,534	6,534	8,174	8,174	8,174	9,322	9,322	13,684	13,684
Length of route parallel to apparent property boundaries	27,632	22,355	19,647	19,647	27,004	24,295	24,295	46,430	49,138	26,423	23,714
Total length of route parallel to existing compatible rights-of-way	142,621	95,205	79,581	101,834	62,888	47,264	69,516	66,005	81,628	90,298	74,674
Number of habitable structures within 500 feet of the route centerline <sup>2</sup>	38	37	37	37	38	38	38	39	39	39	39
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	17,587	16,236	16,440	16,495	13,504	13,708	13,763	13,840	14,118	14,303	14,507
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	300,336	282,007	281,671	274,886	233,317	232,980	226,196	214,958	234,922	245,255	244,919
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	21,851	21,963	24,595	19,421	17,684	20,315	15,141	24,547	22,561	21,000	23,631
Length of route across potential wetlands	1,567	2,318	5,832	2,220	1,382	4,896	1,284	4,803	1,289	1,382	4,896
Number of stream crossings by the route	43	36	36	36	15	15	15	19	19	18	18
Length of route parallel to streams (within 100 feet)	2,885	2,977	2,977	2,977	0	0	0	783	783	581	581
Length across lakes or ponds (open waters)	99	99	99	99	80	80	80	80	80	80	80
Number of known rare/unique plant locations within the right-of-way	0	0	0	0	1	1	1	1	1	1	1
Length of route through known habitat of endangered or threatened species	50	50	50	50	63	63	63	63	63	63	63
Number of recorded cultural resource sites crossed by the route	0	1	1	1	1	1	1	0	0	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	1	4	4	4	2	2	2	0	0	0	0
Length of route across areas of high archaeological/historical site potential	114,392	101,634	98,768	101,634	53,412	50,546	53,412	71,800	74,666	70,758	67,892
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	3	0	0	0	1	1	1	2	2	4	4
Number of U.S. or State Highway crossings by the route	2	2	2	2	3	3	3	3	3	3	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	10	12	12	12	9	9	9	12	12	9	9
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	15,788	14,222	14,222	14,222	20,050	20,050	20,050	21,616	21,616	21,616	21,616
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church. <sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	287	288	289	290	291	292	293	294	295	296	297
Length of alternative route	273,751	332,442	330,396	345,139	314,766	249,191	263,933	272,983	278,996	263,481	240,433
Length of route parallel to existing electric transmission lines	64,596	58,317	23,841	37,565	59,872	0	13,724	39,959	26,235	54,446	0
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	15,479	7,326	16,287	15,479	7,326	16,287	15,479	20,629	21,438	15,479	16,287
Length of route parallel to pipelines <sup>1</sup>	13,684	8,825	8,825	8,825	8,825	8,748	8,748	13,110	13,110	13,110	670
Length of route parallel to apparent property boundaries	23,714	73,899	48,477	51,185	48,477	54,996	57,704	34,968	32,280	32,280	52,931
Total length of route parallel to existing compatible rights-of-way	96,927	132,680	61,744	97,368	108,813	64,422	80,045	88,715	73,091	95,343	62,356
Number of habitable structures within 500 feet of the route centerline <sup>1</sup>	39	39	39	39	39	39	39	39	39	39	38
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	14,562	15,001	15,378	15,655	14,988	13,213	13,491	13,676	13,880	13,935	11,402
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	238,134	273,011	278,176	298,140	266,613	209,668	229,633	239,966	239,629	232,844	201,728
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	18,458	37,241	29,493	27,508	29,309	20,193	18,208	16,646	19,278	14,104	20,404
Length of route across potential wetlands	1,284	5,739	6,036	2,522	2,531	4,803	1,289	1,382	4,896	1,284	5,586
Number of stream crossings by the route	18	20	20	20	24	20	20	19	19	19	17
Length of route parallel to streams (within 100 feet)	581	1,120	1,042	1,042	1,366	783	783	581	581	581	1,001
Length across lakes or ponds (open waters)	80	215	80	80	92	80	80	80	80	80	80
Number of known rare/unique plant locations within the right-of-way	1	2	1	1	1	1	1	1	1	1	1
Length of route through known habitat of endangered or threatened species	63	63	63	63	63	63	63	63	63	63	63
Number of recorded cultural resource sites crossed by the route	0	0	0	0	1	0	0	0	0	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	0	0	0	0	1	0	0	0	0	0	1
Length of route across areas of high archaeological/historical site potential	70,758	73,570	65,759	68,626	74,260	69,303	72,170	68,262	65,395	68,262	64,397
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	4	2	2	2	2	2	2	4	4	4	0
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	9	10	9	9	9	12	12	9	9	9	13
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	21,616	31,476	21,616	21,616	25,124	21,616	21,616	21,616	21,616	21,616	20,298
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church. <sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	298	299	300	301	302	303	304	305	306	307	308
Length of alternative route	255,176	264,225	270,238	254,724	236,084	250,826	259,876	265,888	250,374	299,466	297,421
Length of route parallel to existing electric transmission lines	13,724	39,959	26,235	54,446	10,149	23,873	50,108	36,384	64,596	58,317	23,841
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	15,479	20,629	21,438	15,479	16,287	15,479	20,629	21,438	15,479	7,326	16,287
Length of route parallel to pipelines <sup>1</sup>	670	5,032	5,032	5,032	1,244	1,244	5,606	5,606	5,606	747	747
Length of route parallel to apparent property boundaries	55,639	32,923	30,215	30,215	44,365	47,073	24,357	21,649	21,649	71,834	46,412
Total length of route parallel to existing compatible rights-of-way	77,980	86,649	71,026	93,278	63,940	79,563	88,233	72,609	94,861	130,615	79,679
Number of habitable structures within 500 feet of the route centerline <sup>1</sup>	38	38	38	38	38	38	38	38	38	38	38
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	11,680	11,865	12,069	12,124	11,104	11,381	11,567	11,770	11,826	11,781	12,157
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	221,692	232,025	231,688	224,904	193,445	213,409	223,742	223,405	216,821	242,856	248,021
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	18,419	16,857	19,489	14,315	24,636	22,651	21,089	23,721	18,547	37,067	29,319
Length of route across potential wetlands	2,072	2,164	5,679	2,067	5,586	2,072	2,164	5,679	2,067	6,314	6,611
Number of stream crossings by the route	17	16	16	16	16	16	15	15	15	17	17
Length of route parallel to streams (within 100 feet)	1,001	799	799	799	1,001	1,001	799	799	799	1,338	1,260
Length across lakes or ponds (open waters)	80	80	80	80	80	80	80	80	80	215	80
Number of known rare/unique plant locations within the right-of-way	1	1	1	1	1	1	1	1	1	2	1
Length of route through known habitat of endangered or threatened species	63	63	63	63	63	63	63	63	63	63	63
Number of recorded cultural resource sites crossed by the route	0	0	0	0	0	0	0	0	0	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	1	1	1	1	1	1	1	1	1	1	1
Length of route across areas of high archaeological/historical site potential	67,264	63,356	60,489	63,356	63,063	65,929	62,021	59,155	62,021	64,833	57,022
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	0	2	2	2	0	0	2	2	2	0	0
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	13	10	10	10	13	13	10	10	10	11	10
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	20,298	20,298	20,298	20,298	20,298	20,298	20,298	20,298	20,298	30,159	20,298
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Aeronautics and Space Administration (NASA) digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church.

<sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way.

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	309	310	311	312	313	314	315	316	317	318	319
Length of alternative route	312,183	281,790	301,047	299,002	313,744	283,371	239,531	254,273	263,323	269,335	253,821
<sup>1</sup> Length of route parallel to existing electric transmission lines	37,565	59,872	58,317	23,841	37,565	59,872	0	13,724	39,959	26,235	54,446
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	15,479	7,326	7,326	16,287	15,479	7,326	16,287	15,479	20,629	21,438	15,479
Length of route parallel to pipelines <sup>1</sup>	747	747	747	747	747	747	670	670	5,032	5,032	5,032
Length of route parallel to apparent property boundaries	49,120	46,412	71,834	46,412	49,120	46,412	52,931	55,639	32,923	30,215	30,215
Total length of route parallel to existing compatible rights-of-way	95,302	106,748	130,615	79,679	95,302	106,748	62,356	77,980	86,649	71,026	93,278
Number of habitable structures within 500 feet of the route centerline <sup>1</sup>	38	38	38	38	38	38	38	38	38	38	38
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	12,435	11,767	11,735	12,111	12,389	11,721	11,149	11,427	11,612	11,816	11,871
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	267,985	236,458	244,256	249,422	269,367	237,859	200,853	220,817	231,150	230,813	224,029
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	27,334	29,135	37,292	29,544	27,559	29,360	20,629	18,644	17,083	19,714	14,540
Length of route across potential wetlands	3,096	3,106	6,314	6,611	3,096	3,106	5,586	2,072	2,164	5,679	2,067
Number of stream crossings by the route	17	21	17	17	17	21	17	17	16	16	16
Length of route parallel to streams (within 100 feet)	1,260	1,584	1,338	1,260	1,260	1,584	1,001	1,001	799	799	799
Length across lakes or ponds (open waters)	80	92	215	80	80	92	80	80	80	80	80
Number of known rare/unique plant locations within the right-of-way	1	1	2	1	1	1	1	1	1	1	1
Length of route through known habitat of endangered or threatened species	63	63	63	63	63	63	63	63	63	63	63
Number of recorded cultural resource sites crossed by the route	0	1	0	0	0	1	0	0	0	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	1	2	1	1	1	2	1	1	1	1	1
Length of route across areas of high archaeological/historical site potential	59,888	65,523	64,833	57,022	59,888	65,523	64,397	67,264	63,356	60,489	63,356
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	0	0	0	0	0	0	0	0	2	2	2
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	10	10	11	10	10	10	13	13	10	10	10
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	20,298	23,806	30,159	20,298	20,298	23,806	20,298	20,298	20,298	20,298	20,298
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church.

<sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way.

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	320	321	322	323	324	325	326	327	328	329	330
Length of alternative route	235,181	249,923	258,973	264,986	249,471	283,722	281,677	296,419	266,046	278,897	293,639
Length of route parallel to existing electric transmission lines	10,149	23,873	50,108	36,384	64,596	58,317	23,841	37,565	59,872	0	13,724
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	16,287	15,479	20,629	21,438	15,479	7,844	16,805	15,996	7,844	16,805	15,996
Length of route parallel to pipelines <sup>1</sup>	1,244	1,244	5,606	5,606	5,606	747	747	747	747	670	670
Length of route parallel to apparent property boundaries	44,365	47,073	24,357	21,649	21,649	78,749	53,327	56,035	53,327	72,985	75,693
Total length of route parallel to existing compatible rights-of-way	63,940	79,563	88,233	72,609	94,861	138,047	87,111	102,734	114,180	82,928	98,551
Number of habitable structures within 500 feet of the route centerline <sup>2</sup>	38	38	38	38	38	37	37	37	37	37	37
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	10,851	11,128	11,314	11,517	11,573	9,936	10,313	10,590	9,923	11,791	12,069
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	192,570	212,534	222,867	222,530	215,746	231,612	236,777	256,741	225,214	238,868	258,833
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	24,861	22,876	21,314	23,946	18,772	35,256	27,508	25,523	27,324	22,183	20,198
Length of route across potential wetlands	5,586	2,072	2,164	5,679	2,067	5,470	5,766	2,252	2,261	4,741	1,227
Number of stream crossings by the route	16	16	15	15	15	18	18	18	22	18	18
Length of route parallel to streams (within 100 feet)	1,001	1,001	799	799	799	3,203	3,125	3,125	3,450	2,866	2,866
Length across lakes or ponds (open waters)	80	80	80	80	80	215	80	80	92	80	80
Number of known rare/unique plant locations within the right-of-way	1	1	1	1	1	4	3	3	3	3	3
Length of route through known habitat of endangered or threatened species	63	63	63	63	63	10,532	10,532	10,532	10,532	10,532	10,532
Number of recorded cultural resource sites crossed by the route	0	0	0	0	0	1	1	1	2	1	1
Number of recorded cultural resources within 1,000 feet of the route centerline	1	1	1	1	1	1	1	1	2	1	1
Length of route across areas of high archaeological/historical site potential	63,063	65,929	62,021	59,155	62,021	72,768	64,957	67,823	73,458	72,332	75,198
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	0	0	0	0	0	1	1	1	1	1	1
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	0	0	2	2	2	1	1	1	1	1	1
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (F.M.) county roads or other street crossings by the route	13	13	10	10	10	9	8	8	8	11	11
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	20,298	20,298	20,298	20,298	20,298	32,979	23,119	23,119	26,627	23,119	23,119
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church.

<sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way.

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	331	332	333	334	335	336	337	338	339	340	341
Length of alternative route	302,669	308,702	293,187	274,547	289,290	298,339	304,952	288,838	263,101	277,844	286,893
Length of route parallel to existing electric transmission lines	39,959	26,235	54,446	10,149	23,873	50,108	36,384	64,596	7,925	21,649	47,884
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	21,146	21,955	15,996	16,805	15,996	21,146	21,955	15,996	16,287	15,479	20,629
Length of route parallel to pipelines <sup>1</sup>	5,032	5,032	5,032	1,244	1,244	5,606	5,606	5,606	13,237	13,237	17,599
Length of route parallel to apparent property boundaries	52,977	50,269	50,269	64,419	67,127	44,412	41,703	41,703	50,886	53,594	30,878
Total length of route parallel to existing compatible rights-of-way	107,221	91,597	113,650	84,511	100,135	108,804	93,181	115,433	68,236	83,860	92,529
Number of habitable structures within 500 feet of the route centerline <sup>1</sup>	37	37	37	37	37	37	37	37	37	37	37
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	12,254	12,458	12,513	11,493	11,770	11,955	12,159	12,215	11,805	12,082	12,267
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	269,165	268,829	262,044	230,585	250,550	260,883	260,546	253,762	223,205	243,170	253,502
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	18,636	21,268	16,094	25,415	24,430	22,868	25,499	20,326	21,403	19,418	17,857
Length of route across potential wetlands	1,320	4,834	1,223	4,741	1,227	1,320	4,834	1,223	5,375	1,860	1,953
Number of stream crossings by the route	17	17	17	17	17	16	16	16	15	15	14
Length of route parallel to streams (within 100 feet)	2,665	2,665	2,665	2,866	2,866	2,665	2,665	2,665	201	201	0
Length across lakes or ponds (open waters)	80	80	80	80	80	80	80	80	80	80	80
Number of known rare/unique plant locations within the right-of-way	3	3	3	3	3	3	3	3	3	3	3
Length of route through known habitat of endangered or threatened species	10,532	10,532	10,532	10,532	10,532	10,532	10,532	10,532	10,532	10,532	10,532
Number of recorded cultural resource sites crossed by the route	1	1	1	1	1	1	1	1	1	1	1
Number of recorded cultural resources within 1,000 feet of the route centerline	1	1	1	1	1	1	1	1	1	1	1
Length of route across areas of high archaeological/historical site potential	71,290	68,424	71,290	70,998	73,864	69,956	67,090	69,956	66,009	68,675	64,967
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	1	1	1	1	1	1	1	1	1	1	1
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	3	3	3	1	1	3	3	3	1	1	3
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (FM) county roads, or other street crossings by the route	8	8	8	11	11	8	8	8	11	11	8
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	23,119	23,119	23,119	23,119	23,119	23,119	23,119	23,119	23,119	23,119	23,119
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church. <sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	342	343	344	345	346	347	348	349	350	351	352
Length of alternative route	292,906	277,392	258,752	273,494	282,544	286,556	273,042	322,134	320,089	334,831	304,458
Length of route parallel to existing electric transmission lines	34,159	62,371	18,074	31,798	58,033	44,309	72,520	66,241	31,766	45,490	67,796
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	21,438	15,479	15,287	15,479	20,629	21,438	15,479	7,326	16,287	15,479	7,326
Length of route parallel to pipelines <sup>1</sup>	17,599	17,599	13,611	13,611	18,173	18,173	18,173	13,314	13,314	13,314	13,314
Length of route parallel to apparent property boundaries	28,170	28,170	42,320	45,028	22,313	19,604	19,604	69,789	44,367	47,075	44,367
Total length of route parallel to existing compatible rights-of-way	76,906	99,158	69,820	85,443	94,113	78,499	100,741	136,495	85,559	101,182	112,628
Number of habitable structures within 500 feet of the route centerline <sup>1</sup>	37	37	37	37	37	37	37	37	37	37	37
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	12,471	12,526	11,506	11,783	11,969	12,173	12,228	12,183	12,559	12,837	12,169
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	253,166	245,361	214,922	234,687	245,219	244,883	238,098	264,334	269,498	289,463	257,935
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	20,488	15,314	25,635	23,650	22,089	24,720	19,546	38,066	30,318	28,333	30,134
Length of route across potential wetlands	5,468	1,856	5,375	1,860	1,953	5,468	1,856	6,103	6,400	2,885	2,894
Number of stream crossings by the route	14	14	14	14	13	13	13	15	15	15	19
Length of route parallel to streams (within 100 feet)	0	0	201	201	0	0	0	538	461	461	785
Length across lakes or ponds (open waters)	80	80	80	80	80	80	80	215	80	80	92
Number of known rare/unique plant locations within the right-of-way	3	3	3	3	3	3	3	4	3	3	3
Length of route through known habitat of endangered or threatened species	10,532	10,532	10,532	10,532	10,532	10,532	10,532	10,532	10,532	10,532	10,532
Number of recorded cultural resource sites crossed by the route	1	1	1	1	1	1	1	1	1	1	2
Number of recorded cultural resources within 1,000 feet of the route centerline	1	1	1	1	1	1	1	1	1	1	2
Length of route across areas of high archaeological/historical site potential	62,101	64,967	64,674	67,540	63,633	60,766	63,633	66,445	58,634	61,500	67,134
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	1	1	1	1	1	1	1	1	1	1	1
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	3	3	1	1	3	3	3	1	1	1	1
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	8	8	11	11	8	8	8	9	8	8	8
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	23,119	23,119	23,119	23,119	23,119	23,119	23,119	32,979	23,119	23,119	26,627
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church.

<sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way.

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	353	354	355	356	357	358	359	360	361	362	363
Length of alternative route	323,715	321,670	336,412	306,039	262,198	276,941	285,990	292,003	276,488	257,849	272,591
Length of route parallel to existing electric transmission lines	66,241	31,766	45,490	67,796	7,925	21,549	47,884	34,159	62,371	18,074	31,788
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	7,326	16,287	15,479	7,326	16,287	15,479	20,629	21,438	15,479	16,287	15,479
Length of route parallel to pipelines <sup>1</sup>	13,314	13,314	13,314	13,314	13,237	13,237	17,599	17,599	17,599	13,811	13,811
Length of route parallel to apparent property boundaries	69,789	44,357	47,075	44,367	50,886	53,594	30,878	28,170	28,170	42,320	45,028
Total length of route parallel to existing compatible rights-of-way	136,495	85,559	101,182	112,628	68,236	83,850	92,529	76,906	99,158	69,820	85,443
Number of habitable structures within 500 feet of the route centerline <sup>2</sup>	37	37	37	37	37	37	37	37	37	37	37
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	12,137	12,514	12,791	12,123	11,552	11,829	12,014	12,218	12,273	11,253	11,530
Length of the route across cropland/hay meadow	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233
Length across rangeland/pasture	265,735	270,900	290,864	259,337	222,330	242,295	252,627	252,291	245,506	214,047	234,012
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	38,291	30,544	28,558	30,359	21,629	19,643	18,082	20,713	15,540	25,860	23,875
Length of route across potential wetlands	6,103	6,400	2,885	2,894	5,375	1,860	1,953	5,468	1,856	5,375	1,860
Number of stream crossings by the route	15	15	15	19	15	15	14	14	14	14	14
Length of route parallel to streams (within 100 feet)	538	461	461	785	201	201	0	0	0	201	201
Length across lakes or ponds (open waters)	215	80	80	92	80	80	80	80	80	80	80
Number of known rare/unique plant locations within the right-of-way	4	3	3	3	3	3	3	3	3	3	3
Length of route through known habitat of endangered or threatened species	10,532	10,532	10,532	10,532	10,532	10,532	10,532	10,532	10,532	10,532	10,532
Number of recorded cultural resource sites crossed by the route	1	1	1	2	1	1	1	1	1	1	1
Number of recorded cultural resources within 1,000 feet of the route centerline	1	1	1	2	1	1	1	1	1	1	1
Length of route across areas of high archaeological/historical site potential	66,445	58,634	61,500	67,134	66,009	68,875	64,967	62,101	64,967	64,674	67,540
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	1	1	1	1	1	1	1	1	1	1	1
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	1	1	1	1	1	1	3	3	3	1	1
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	9	8	8	8	11	11	8	8	8	11	11
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	32,979	23,119	23,119	26,627	23,119	23,119	23,119	23,119	23,119	23,119	23,119
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church. <sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	364	365	366	367	368	369	370	371	372	373	374
Length of alternative route	281,641	287,653	272,139	323,208	321,162	335,905	305,532	318,382	333,125	342,174	348,187
Length of route parallel to existing electric transmission lines	58,033	44,309	72,520	58,317	23,841	37,565	59,872	0	13,724	39,959	26,235
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	20,629	21,438	15,479	21,892	30,853	30,045	21,892	30,853	30,045	35,195	36,004
Length of route parallel to pipelines <sup>1</sup>	18,173	18,173	18,173	3,460	3,460	3,460	3,460	3,383	3,383	7,746	7,746
Length of route parallel to apparent property boundaries	22,313	19,604	19,604	98,494	73,073	75,761	73,073	92,731	95,439	72,723	70,015
Total length of route parallel to existing compatible rights-of-way	94,113	78,489	100,741	159,388	108,452	124,076	135,522	104,269	119,893	128,562	112,939
Number of habitable structures within 500 feet of the route centerline <sup>1</sup>	37	37	37	66	66	66	66	66	66	66	66
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	11,716	11,920	11,975	8,590	8,967	9,244	8,577	10,445	10,723	10,908	11,112
Length of the route across cropland/hay meadow	1,233	1,233	1,233	7,177	7,177	7,177	7,177	7,177	7,177	7,177	7,177
Length across rangeland/pasture	244,345	244,008	237,223	265,214	270,379	290,343	258,816	272,470	292,434	302,767	302,430
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	0	0	0	3,043	3,043	3,043	3,043	3,043	3,043	3,043	3,043
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	22,314	24,945	19,771	32,516	24,769	22,783	24,584	19,444	17,458	15,897	18,528
Length of route across potential wetlands	1,953	5,468	1,856	6,462	6,758	3,244	3,253	5,734	2,219	2,312	5,826
Number of stream crossings by the route	13	13	13	22	22	22	26	22	22	21	21
Length of route parallel to streams (within 100 feet)	0	0	0	4,203	4,125	4,125	4,449	3,865	3,865	3,664	3,664
Length across lakes or ponds (open waters)	80	80	80	206	70	70	83	70	70	70	70
Number of known rare/unique plant locations within the right-of-way	3	3	3	2	1	1	1	1	1	1	1
Length of route through known habitat of endangered or threatened species	10,532	10,532	10,532	52	52	52	52	52	52	52	52
Number of recorded cultural resource sites crossed by the route	1	1	1	0	0	0	1	0	0	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	1	1	1	0	0	0	1	0	0	0	0
Length of route across areas of high archaeological/historical site potential	63,633	60,766	63,633	49,239	41,428	44,294	49,928	48,802	51,669	47,761	44,895
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	1	1	1	2	2	2	2	2	2	2	2
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	0	0	0	1	1	1	1	1	1	1	1
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	3	3	3	0	0	0	0	0	0	2	2
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	8	8	8	17	16	16	16	19	19	16	16
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	23,119	23,119	23,119	34,986	25,128	25,128	28,636	25,128	25,128	25,128	25,128
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church.

<sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way.

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	375	376	377	378	379	380	381	382	383	384	385
Length of alternative route	332,673	314,033	328,775	337,825	343,837	328,323	302,586	317,329	326,378	332,391	316,877
Length of route parallel to existing electric transmission lines	54,446	10,149	23,873	50,108	36,384	64,596	7,925	21,649	47,884	34,159	62,371
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	30,045	30,853	30,045	35,195	36,004	30,045	30,336	29,527	34,678	35,486	29,527
Length of route parallel to pipelines <sup>1</sup>	7,746	3,957	3,957	8,320	8,320	8,320	15,950	15,950	20,312	20,312	20,312
Length of route parallel to apparent property boundaries	70,015	84,165	86,873	64,157	61,449	61,449	70,632	73,340	50,624	47,916	47,916
Total length of route parallel to existing compatible rights-of-way	135,191	105,853	121,476	130,146	114,522	136,774	89,578	105,201	113,871	98,247	120,499
Number of habitable structures within 500 feet of the route centerline <sup>1</sup>	66	66	66	66	66	66	66	66	66	66	66
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	11,167	10,147	10,424	10,610	10,813	10,889	10,459	10,736	10,922	11,125	11,181
Length of the route across cropland/hay meadow	7,177	7,177	7,177	7,177	7,177	7,177	7,177	7,177	7,177	7,177	7,177
Length across rangeland/pasture	295,646	264,187	284,152	294,484	294,148	287,363	256,807	276,771	287,104	286,767	279,983
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	3,043	3,043	3,043	3,043	3,043	3,043	3,043	3,043	3,043	3,043	3,043
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	13,355	23,675	21,690	20,129	22,760	17,586	18,664	16,679	15,117	17,749	12,575
Length of route across potential wetlands	2,215	5,734	2,219	2,312	5,826	2,215	6,367	2,853	2,945	6,460	2,848
Number of stream crossings by the route	21	21	21	20	20	20	19	19	18	18	18
Length of route parallel to streams (within 100 feet)	3,664	3,665	3,665	3,664	3,664	3,664	1,201	1,201	1,000	1,000	1,000
Length across lakes or ponds (open waters)	70	70	70	70	70	70	70	70	70	70	70
Number of known rare/unique plant locations within the right-of-way	1	1	1	1	1	1	1	1	1	1	1
Length of route through known habitat of endangered or threatened species	52	52	52	52	52	52	52	52	52	52	52
Number of recorded cultural resource sites crossed by the route	0	0	0	0	0	0	0	0	0	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Length of route across areas of high archaeological/historical site potential	47,761	47,468	50,334	46,427	43,560	46,427	42,479	45,346	41,438	38,571	41,438
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	2	2	2	2	2	2	2	2	2	2	2
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	1	1	1	1	1	1	1	1	1	1	1
Number of FM microwave and other electronic installations within 2,000 feet of the route centerline	2	0	0	2	2	2	0	0	2	2	2
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	16	19	19	16	16	16	19	19	16	16	16
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	25,128	25,128	25,128	25,128	25,128	25,128	25,128	25,128	25,128	25,128	25,128
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church. <sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	386	387	388	389	390	391	392	393	394	395	396
Length of alternative route	298,237	312,979	322,029	328,041	312,527	361,619	359,574	374,317	343,944	363,200	361,155
Length of route parallel to existing electric transmission lines	18,074	31,798	58,033	44,309	72,520	66,241	31,766	45,490	67,796	66,241	31,766
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	30,336	29,527	34,678	35,466	29,527	21,375	30,336	29,527	21,375	21,375	30,336
Length of route parallel to pipelines <sup>1</sup>	16,524	16,524	20,886	20,886	20,886	16,027	16,027	16,027	16,027	16,027	16,027
Length of route parallel to apparent property boundaries	62,066	64,774	42,059	39,350	39,350	89,535	64,113	66,821	64,113	89,535	64,113
Total length of route parallel to existing compatible rights-of-way	91,161	106,785	115,454	99,830	122,083	157,836	106,900	122,524	133,969	157,836	106,900
Number of habitable structures within 500 feet of the route centerline <sup>1</sup>	66	66	66	66	66	66	66	66	66	66	66
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	10,160	10,436	10,623	10,827	10,882	10,837	11,213	11,491	10,823	10,791	11,168
Length of the route across cropland/ hay meadow	7,177	7,177	7,177	7,177	7,177	7,177	7,177	7,177	7,177	7,177	7,177
Length across rangeland/pasture	248,524	268,488	278,821	278,484	271,700	297,936	303,100	323,065	291,537	299,337	304,501
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	3,043	3,043	3,043	3,043	3,043	3,043	3,043	3,043	3,043	3,043	3,043
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	22,896	20,911	19,349	21,981	16,807	35,327	27,579	25,594	27,395	35,552	27,804
Length of route across potential wetlands	6,367	2,853	2,945	6,480	2,848	7,095	7,392	3,877	3,886	7,095	7,392
Number of stream crossings by the route	18	18	17	17	17	19	19	19	23	19	19
Length of route parallel to streams (within 100 feet)	1,201	1,201	1,000	1,000	1,000	1,538	1,460	1,460	1,785	1,538	1,460
Length across lakes or ponds (open waters)	70	70	70	70	70	206	70	70	83	206	70
Number of known rare/unique plant locations within the right-of-way	1	1	1	1	1	2	1	1	1	2	1
Length of route through known habitat of endangered or threatened species	52	52	52	52	52	52	52	52	52	52	52
Number of recorded cultural resource sites crossed by the route	0	0	0	0	0	0	0	0	1	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	0	0	0	0	0	0	0	0	1	0	0
Length of route across areas of high archaeological/historical site potential	41,145	44,011	40,103	37,237	40,103	42,915	35,104	37,670	43,605	42,915	35,104
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	2	2	2	2	2	2	2	2	2	2	2
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	1	1	1	1	1	1	1	1	1	1	1
Number of FM microwave and other electronic installations within 2,000 feet of the route centerline	0	0	2	2	2	0	0	0	0	0	0
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	19	19	16	16	16	17	16	16	16	17	16
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	25,128	25,128	25,128	25,128	25,128	34,988	25,128	25,128	28,636	34,988	25,128
Estimated length of right-of-way within foreground visual zone of parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church.

<sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way.

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	397	398	399	400	401	402	403	404	405	406	407
Length of alternative route	375,897	345,524	301,684	316,426	325,476	331,488	315,974	297,334	312,077	321,126	327,139
Length of route parallel to existing electric transmission lines	45,490	67,796	7,925	21,649	47,884	34,159	62,371	18,074	31,798	58,033	44,309
Length of route parallel to railroads	0	0	0	0	0	0	0	0	0	0	0
Length of route parallel to existing public roads/highways	29,527	21,375	30,336	29,527	34,678	35,486	29,527	30,336	29,527	34,678	35,486
Length of route parallel to pipelines <sup>1</sup>	16,027	16,027	15,950	15,950	20,312	20,312	20,312	16,524	16,524	20,886	20,886
Length of route parallel to apparent property boundaries	66,821	64,113	70,632	73,340	50,624	47,916	47,916	62,066	64,774	42,059	39,350
Total length of route parallel to existing compatible rights-of-way	122,524	133,969	89,578	105,201	113,871	98,247	120,499	91,161	106,785	115,454	99,830
Number of habitable structures within 500 feet of the route centerline <sup>2</sup>	66	66	66	66	66	66	66	66	66	66	66
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0	0	0	0	0	0	0	0	0	0	0
Length of the route across parks/recreational areas	0	0	0	0	0	0	0	0	0	0	0
Length of route through commercial/industrial areas	11,445	10,777	10,206	10,483	10,668	10,672	10,928	9,907	10,185	10,370	10,574
Length of the route across cropland/hay meadow	7,177	7,177	7,177	7,177	7,177	7,177	7,177	7,177	7,177	7,177	7,177
Length across rangeland/pasture	324,466	292,938	255,932	275,896	286,229	285,892	279,108	247,649	267,613	277,946	277,610
Length of route across agricultural cropland with mobile irrigation systems <sup>2</sup>	3,043	3,043	3,043	3,043	3,043	3,043	3,043	3,043	3,043	3,043	3,043
Length of route across upland woodlands	0	0	0	0	0	0	0	0	0	0	0
Length of route across riparian areas	25,819	27,620	18,889	16,904	15,343	17,974	12,800	23,121	21,136	19,575	22,206
Length of route across potential wetlands	3,877	3,886	6,367	2,853	2,945	6,460	2,848	6,367	2,853	2,945	6,460
Number of stream crossings by the route	19	23	19	19	18	18	18	18	18	17	17
Length of route parallel to streams (within 100 feet)	1,460	1,785	1,201	1,201	1,000	1,000	1,000	1,201	1,201	1,000	1,000
Length across lakes or ponds (open waters)	70	83	70	70	70	70	70	70	70	70	70
Number of known rare/unique plant locations within the right-of-way	1	1	1	1	1	1	1	1	1	1	1
Length of route through known habitat of endangered or threatened species	52	52	52	52	52	52	52	52	52	52	52
Number of recorded cultural resource sites crossed by the route	0	1	0	0	0	0	0	0	0	0	0
Number of recorded cultural resources within 1,000 feet of the route centerline	0	1	0	0	0	0	0	0	0	0	0
Length of route across areas of high archaeological/historical site potential	37,970	43,605	42,479	45,346	41,438	38,571	41,438	41,145	44,011	40,103	37,237
Number of private airstrips within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	2	2	2	2	2	2	2	2	2	2	2
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of heliports located within 5,000 feet of the route centerline	0	0	0	0	0	0	0	0	0	0	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	1	1	1	1	1	1	1	1	1	1	1
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	0	0	0	0	2	2	2	0	0	2	2
Number of U.S. or State Highway crossings by the route	3	3	3	3	3	3	3	3	3	3	3
Number of Farm to Market (F.M.), county roads, or other street crossings by the route	16	16	19	19	16	16	16	19	19	16	16
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	25,128	28,636	25,128	25,128	25,128	25,128	25,128	25,128	25,128	25,128	25,128
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0	0	0	0	0	0	0	0	0	0	0

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church.

<sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way.

**Table 7-2. Environmental Data for Alternative Route Evaluation  
Sand Lake—Solstice 345 kV Transmission Line Project**

Alternative Route Number	408
Length of alternative route	311,624
Length of route parallel to existing electric transmission lines	72,520
Length of route parallel to railroads	0
Length of route parallel to existing public roads/highways	29,527
Length of route parallel to pipelines <sup>1</sup>	20,886
Length of route parallel to apparent property boundaries	39,350
Total length of route parallel to existing compatible rights-of-way	122,083
Number of habitable structures within 500 feet of the route centerline <sup>1</sup>	66
Number of parks or recreational areas within 1,000 feet of the route centerline <sup>2</sup>	0
Length of the route across parks/recreational areas	0
Length of route through commercial/industrial areas	10,629
Length of the route across cropland/hay meadow	7,177
Length across rangeland/pasture	270,825
Length of route across agricultural cropland with mobile irrigation systems <sup>3</sup>	3,043
Length of route across upland woodlands	0
Length of route across riparian areas	17,032
Length of route across potential wetlands	2,948
Number of stream crossings by the route	17
Length of route parallel to streams (within 100 feet)	1,000
Length across lakes or ponds (open waters)	70
Number of known rare/unique plant locations within the right-of-way	1
Length of route through known habitat of endangered or threatened species	52
Number of recorded cultural resource sites crossed by the route	0
Number of recorded cultural resources within 1,000 feet of the route centerline	0
Length of route across areas of high archaeological/historical site potential	40,103
Number of private airstrips within 10,000 feet of the route centerline	0
Number of FAA-registered airports with at least one runway more than 3,200 feet in length within 20,000 feet of route centerline	2
Number of FAA-registered airports with no runway greater than 3,200 feet in length within 10,000 feet of the route centerline	0
Number of heliports located within 5,000 feet of the route centerline	0
Number of commercial AM radio transmitters located within 10,000 feet of the route centerline	1
Number of FM, microwave and other electronic installations within 2,000 feet of the route centerline	2
Number of U.S. or State Highway crossings by the route	3
Number of Farm to Market (F.M.) county roads, or other street crossings by the route	16
Estimated length of right-of-way within foreground visual zone of U.S. and State Highways	25,128
Estimated length of right-of-way within foreground visual zone of park/recreational areas	0

End of Table

**Note:** All length measurements in feet. All linear measurements were obtained from the National Agricultural Imagery Program digital ortho imagery flown in 2016-2017 with the exception of areas of high archaeological/historical site potential which were measured from USGS Topographic Quadrangles. The aerial photograph has a provided accuracy of +/- 30 feet. <sup>1</sup>Structures normally inhabited by humans on a daily or regular basis. Habitable structures include but are not limited to a single-family and multi-family dwellings and related structures, mobile homes, apartment buildings, commercial structures, industrial structures, churches, hospitals, nursing homes, and schools. <sup>2</sup>Defined as parks and recreational areas owned by a governmental body or an organized group, club, or church. <sup>3</sup>Believed to be systems no longer in use.

\* - Not included in length of route parallel to existing compatible rights-of-way

**Appendix F**  
**Habitable Structures within 500 Feet of the Alternative Links**

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**TABLE 7-3. HABITABLE STRUCTURES WITHIN 500 FEET OF ALTERNATIVE LINKS**

Habitable Structure	Distance†	Description	Direction*	Link	Habitable Structure	Distance†	Description	Direction*	Link
1	226	SFR‡	NNE	B2	35	339	SFR	NNE	B2
2	264	MLU①	NNE	B2	36	398	Industrial	NNE	C1
3	264	MLU	NNE	B2	37	424	SFR	NNE	C1
4	264	MLU	NW	B2	38	379	SFR	NNE	C1
5	264	MLU	SE	B2	39	309	MLU	NNE	C1
6	264	MLU	NW	B2	40	313	MLU	NNE	C1
7	264	MLU	NW	B2	41	311	MLU	NNE	C1
8	264	MLU	NW	B2	42	350	MLU	NNE	C1
9	484	MLU	SSE	B2	43	351	MLU	NNE	C1
10	484	MLU	SSE	B2	44	348	MLU	NNE	C1
11	481	MLU	NE	B2	45	352	MLU	NNE	C1
12	481	MLU	NW	B2	46	347	MLU	NNE	C1
13	440	MLU	NW	B2	47	374	MLU	NNE	C1
14	440	MLU	NW	B2	48	361	MLU	NNE	C1
15	439	MLU	NW	B2	49	381	MLU	NNE	C1
16	439	MLU	NW	B2	50	503	SFR	NNE	C1
17	439	MLU	NW	B2	51	376	MOU②	SE	C1
18	439	MLU	NW	B2	52	376	MOU	SE	C1
19	439	MLU	NW	B2	53	376	MOU	SE	C1
20	439	MLU	NW	B2	54	376	MOU	SE	C1
21	206	SFR	NW	B2	55	376	MOU	SE	C1
22	266	MLU	W	B2	56	376	MOU	SE	C1
23	266	MLU	S	B2	57	376	MOU	SE	C1
24	266	MLU	SSW	B2	58	376	MOU	SE	C1
25	266	MLU	ENE	B2	59	376	MOU	SE	C1
26	266	MLU	NNE	B2	60	376	MOU	SE	C1
27	266	MLU	NNE	B2	61	376	MOU	SE	C1
28	266	MLU	NNE	B2	62	491	Industrial	SE	C1
29	266	MLU	NNE	B2	63	451	Industrial	SE	C1
30	266	MLU	NNE	B2	64	280	Industrial	SE	C1
31	266	MLU	NNE	B2	65	248	SFR	NE	D2
32	266	MLU	NNE	B2	66	490	Industrial	W	H1
33	266	MLU	NNE	B2	67	491	MOU	SW	Z
34	383	MLU	NNE	B2	68	405	MOU	SW	Z

End of Table 7-3

**Notes:**

\* Direction represents the distance beginning from the habitable structure towards the provided link

† Measurements greater than 500 feet account for measurements obtained from Digital Globe (DigitalGlobe, 2016; 2017) aerial photography, with a recorded accuracy of 10 16 meters (or approximately 30 feet) to true ground location

‡ Denotes single family residence with a permanent foundation

① Denotes mobile livings units. These units have no permanent foundation and are in the travel trailer style. These features are distinguished as clusters (orange diamonds) on **Figures 3-1A and 3-1B**.

② Denotes a mobile office unit, associated primarily with oil and gas facilities construction sites. These are prefabricated mobile units brought to these sites temporarily until completion of the project.

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**Appendix G**  
**Environmental and Land Use Constraints Maps**

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Robert Holt  
Director  
Transmission Services

October 19, 2018

Oncor | Transmission Services  
2233-B Mountain Creek Parkway  
Dallas, TX 75211

Tel 214 743 6812  
Fax 972 263 6710  
Cell 817 975 1856  
robert.holt@oncor.com

Ms. Judith Talavera  
President  
AEP Texas, Inc.  
539 N. Carancahua  
Floor 17  
Corpus Christi, TX 78401

Re: AEP Texas Solstice to Oncor Sand Lake 345-kV Double-Circuit Transmission  
CCN Application Project

Dear Ms. Talavera,

This letter will confirm the agreement ("Letter Agreement") between AEP Texas Inc. ("AEP Texas") and Oncor Electric Delivery Company, LLC ("Oncor") (each a "Party" and collectively, the "Parties") concerning the sharing of third-party consultant costs associated with environmental and alternative routing analysis, aerial mapping, and landowner identification services for the AEP Texas Solstice to Oncor Sand Lake Double-Circuit 345-kV transmission line certificate of convenience and necessity ("CCN") application (the "Project").

1. The Parties agree to select as consultants Halff Associates Inc. and TRC Solutions (all collectively referred to as "Third Party Consultants") in support of their joint application to the Public Utility Commission of Texas ("PUC") to amend each Party's respective CCN(s) for the Project.

2. The services will include Halff Associates Inc. (a) providing all PUC required environmental and land use data acquisition and analysis, (b) assisting in and preparing for open houses, (c) conducting a routing study and environmental report in accordance with applicable PUC statutory and regulatory routing guidelines, (d) producing the documentation necessary for the CCN application, and (e) providing assistance during the CCN application process, which is anticipated to include responding to discovery, preparing testimony and testifying, and performing any additional route development and analysis determined to be necessary by the Parties. Halff Associates Inc. will also provide aerial mapping. TRC Solutions will provide deed mapping services as necessary for routing analysis by Halff Associates Inc. and landowner maps required for the CCN application. TRC Solutions will also provide landowner identification services for open house(s), the CCN application, and the final notice once the CCN is approved.

3. Oncor will execute agreements with the Third Party Consultants to provide the services described in Paragraph 2. AEP Texas and Oncor will each be responsible for fifty percent (50%) of the Third Party Consultants' respective invoices for the Project, subject to any costs that were specific to one of the Parties (e.g., if one of the consultants provided services to a party that was not part of the Project). Each Party shall be responsible for all of its own internal costs related to the Project.

ATTACHMENT NO. 2

1

4. The Parties shall each have an equal right to direct the Third Party Consultants pursuant to the agreements entered into under this Agreement, including the right to attend any conferences and receive any materials prepared by the Third Party Consultants pertaining to this Project. Should the Parties disagree concerning the direction of the Third Party Consultants, one senior manager designated by each Party shall meet and negotiate in good faith to resolve the differences.

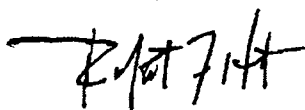
5. The Third Party Consultants shall bill Oncor for their services related to the Project, and Oncor will in turn provide a copy of the Third Party Consultant's invoices to AEP Texas (with reasonable supporting details as may be requested by AEP Texas) and bill AEP Texas for fifty percent (50%) of those costs. AEP Texas agrees that it will pay to Oncor its share of the Third Party Consultants' invoiced amounts within thirty days from the date that Oncor presents an invoice for those costs.

6. This Letter Agreement will terminate upon issuance of a final order by the PUC and issuance of notice to affected landowners in the proceeding seeking approval of the CCN amendments for the Project, and once all payments have been made to the Third Party Consultants for services provided pertaining to the conclusion of the CCN proceeding, unless the Parties agree in writing to terminate the Letter Agreement at an earlier date.

7. AEP Texas and Oncor agree that after final PUC approval of the Project, or as otherwise directed by the Commission, the Parties will negotiate in good faith to determine an appropriate location along the approved route for a division of ownership between AEP Texas and Oncor that will generally divide the line in two even parts. AEP Texas and Oncor agree that each Party will be responsible for construction and operation of its individual portion of the Project.


If AEP Texas agrees that this Letter Agreement sets forth the terms and conditions agreed upon by AEP Texas and Oncor, please countersign this Letter Agreement in the space provided below and return a signed copy to me. Please contact Chris Reily at (214) 486-4717 if you have any questions.

Sincerely,



Robert Holt  
Director, Transmission Services

Agreed and accepted as of October 5, 2018:



Judith Talavera  
President  
AEP Texas Inc.

**Sand Lake - Solstice 345 kV Transmission Line Project**

**Attachment No. 3 - Estimated Costs**

	Route 3	Route 13	Route 14	Route 18	Route 41	Route 46	Route 49	Route 78
Right-of-way and Land Acquisition	\$10,250,000	\$9,922,000	\$10,496,000	\$9,574,000	\$9,369,000	\$11,255,000	\$10,578,000	\$10,414,000
Engineering and Design (Utility)	\$2,375,000	\$2,298,000	\$2,431,000	\$2,219,000	\$2,172,000	\$2,608,000	\$2,449,000	\$2,415,000
Engineering and Design (Contract)	\$2,858,000	\$2,811,000	\$2,893,000	\$2,762,000	\$2,731,000	\$3,005,000	\$2,905,000	\$2,884,000
Procurement of Material and Equipment (including stores)	\$37,243,000	\$36,991,000	\$38,969,000	\$35,035,000	\$34,098,000	\$40,306,000	\$38,530,000	\$38,917,000
Construction of Facilities (Utility)	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000
Construction of Facilities (Contract)	\$56,137,000	\$55,792,000	\$58,862,000	\$52,817,000	\$51,447,000	\$60,805,000	\$58,212,000	\$58,726,000
Other (all costs not included in the above categories)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
<b>Estimated Total Transmission Line Cost</b>	<b>\$108,864,000</b>	<b>\$107,815,000</b>	<b>\$113,652,000</b>	<b>\$102,408,000</b>	<b>\$99,818,000</b>	<b>\$117,980,000</b>	<b>\$112,675,000</b>	<b>\$113,357,000</b>
Estimated Oncor Substation Facilities Cost	\$17,600,000	\$17,600,000	\$17,600,000	\$17,600,000	\$17,600,000	\$17,600,000	\$17,600,000	\$17,600,000
Estimated AEP Texas Substation Facilities Cost	\$10,111,000	\$10,111,000	\$10,111,000	\$10,111,000	\$10,111,000	\$10,111,000	\$10,111,000	\$10,111,000
<b>Estimated Total Project Cost</b>	<b>\$136,575,000</b>	<b>\$135,526,000</b>	<b>\$141,363,000</b>	<b>\$130,119,000</b>	<b>\$127,529,000</b>	<b>\$145,691,000</b>	<b>\$140,386,000</b>	<b>\$141,068,000</b>

**Sand Lake - Solstice 345 kV Transmission Line Project**

**Attachment No. 3 - Estimated Costs**

	Route 90	Route 131	Route 183	Route 280	Route 281	Route 282	Route 292	Route 293
Right-of-way and Land Acquisition	\$10,824,000	\$10,517,000	\$12,034,000	\$10,373,000	\$10,599,000	\$10,004,000	\$9,676,000	\$10,250,000
Engineering and Design (Utility)	\$2,509,000	\$2,437,000	\$2,789,000	\$2,405,000	\$2,458,000	\$2,320,000	\$2,243,000	\$2,376,000
Engineering and Design (Contract)	\$2,943,000	\$2,898,000	\$3,118,000	\$2,876,000	\$2,910,000	\$2,823,000	\$2,776,000	\$2,858,000
Procurement of Material and Equipment (including stores)	\$38,828,000	\$38,705,000	\$43,384,000	\$37,768,000	\$38,622,000	\$36,732,000	\$36,480,000	\$38,458,000
Construction of Facilities (Utility)	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000
Construction of Facilities (Contract)	\$58,594,000	\$58,423,000	\$65,577,000	\$56,977,000	\$58,191,000	\$55,386,000	\$55,041,000	\$58,111,000
Other (all costs not included in the above categories)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
<b>Estimated Total Transmission Line Cost</b>	<b>\$113,699,000</b>	<b>\$112,981,000</b>	<b>\$126,903,000</b>	<b>\$110,400,000</b>	<b>\$112,781,000</b>	<b>\$107,266,000</b>	<b>\$106,217,000</b>	<b>\$112,054,000</b>
Estimated Oncor Substation Facilities Cost	\$17,600,000	\$17,600,000	\$17,600,000	\$17,600,000	\$17,600,000	\$17,600,000	\$17,600,000	\$17,600,000
Estimated AEP Texas Substation Facilities Cost	\$10,111,000	\$10,111,000	\$10,111,000	\$10,111,000	\$10,111,000	\$10,111,000	\$10,111,000	\$10,111,000
<b>Estimated Total Project Cost</b>	<b>\$141,410,000</b>	<b>\$140,692,000</b>	<b>\$154,614,000</b>	<b>\$138,111,000</b>	<b>\$140,492,000</b>	<b>\$134,977,000</b>	<b>\$133,928,000</b>	<b>\$139,765,000</b>

**Sand Lake - Solstice 345 kV Transmission Line Project**

**Attachment No. 3 - Estimated Costs**

	Route 296	Route 297	Route 310	Route 320	Route 324	Route 325	Route 326	Route 328
Right-of-way and Land Acquisition	\$10,230,000	\$9,328,000	\$10,947,000	\$9,123,000	\$9,676,000	\$11,009,000	\$10,927,000	\$10,332,000
Engineering and Design (Utility)	\$2,373,000	\$2,164,000	\$2,536,000	\$2,117,000	\$2,247,000	\$2,553,000	\$2,535,000	\$2,394,000
Engineering and Design (Contract)	\$2,856,000	\$2,727,000	\$2,958,000	\$2,696,000	\$2,776,000	\$2,970,000	\$2,958,000	\$2,870,000
Procurement of Material and Equipment (including stores)	\$38,921,000	\$34,524,000	\$39,723,000	\$33,587,000	\$36,028,000	\$39,795,000	\$38,914,000	\$38,019,000
Construction of Facilities (Utility)	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000
Construction of Facilities (Contract)	\$58,889,000	\$52,066,000	\$59,901,000	\$50,696,000	\$54,544,000	\$60,054,000	\$58,716,000	\$57,461,000
Other (all costs not included in the above categories)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
<b>Estimated Total Transmission Line Cost</b>	<b>\$113,270,000</b>	<b>\$100,810,000</b>	<b>\$116,066,000</b>	<b>\$98,220,000</b>	<b>\$105,272,000</b>	<b>\$116,382,000</b>	<b>\$114,051,000</b>	<b>\$111,077,000</b>
Estimated Oncor Substation Facilities Cost	\$17,600,000	\$17,600,000	\$17,600,000	\$17,600,000	\$17,600,000	\$17,600,000	\$17,600,000	\$17,600,000
Estimated AEP Texas Substation Facilities Cost	\$10,111,000	\$10,111,000	\$10,111,000	\$10,111,000	\$10,111,000	\$10,111,000	\$10,111,000	\$10,111,000
<b>Estimated Total Project Cost</b>	<b>\$140,981,000</b>	<b>\$128,521,000</b>	<b>\$143,777,000</b>	<b>\$125,931,000</b>	<b>\$132,983,000</b>	<b>\$144,093,000</b>	<b>\$141,762,000</b>	<b>\$138,788,000</b>

**Sand Lake - Solstice 345 kV Transmission Line Project**

**Attachment No. 3 - Estimated Costs**

	<b>Route 329</b>	<b>Route 357</b>	<b>Route 366</b>	<b>Route 370</b>	<b>Route 404</b>
Right-of-way and Land Acquisition	\$10,824,000	\$10,189,000	\$10,558,000	\$11,870,000	\$11,542,000
Engineering and Design (Utility)	\$2,510,000	\$2,360,000	\$2,451,000	\$2,750,000	\$2,677,000
Engineering and Design (Contract)	\$2,943,000	\$2,849,000	\$2,904,000	\$3,093,000	\$3,047,000
Procurement of Material and Equipment (including stores)	\$40,312,000	\$38,406,000	\$40,205,000	\$42,183,000	\$41,928,000
Construction of Facilities (Utility)	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000
Construction of Facilities (Contract)	\$60,566,000	\$57,975,000	\$60,914,000	\$63,560,000	\$63,165,000
Other (all costs not included in the above categories)	\$0	\$0	\$0	\$0	\$0
<b>Estimated Total Transmission Line Cost</b>	<b>\$117,156,000</b>	<b>\$111,780,000</b>	<b>\$117,033,000</b>	<b>\$123,457,000</b>	<b>\$122,360,000</b>
Estimated Oncor Substation Facilities Cost	\$17,600,000	\$17,600,000	\$17,600,000	\$17,600,000	\$17,600,000
Estimated AEP Texas Substation Facilities Cost	\$10,111,000	\$10,111,000	\$10,111,000	\$10,111,000	\$10,111,000
<b>Estimated Total Project Cost</b>	<b>\$144,867,000</b>	<b>\$139,491,000</b>	<b>\$144,744,000</b>	<b>\$151,168,000</b>	<b>\$150,071,000</b>

June 12, 2018

Mr. Robert W. Bradish  
Vice President, Grid Development  
American Electric Power  
700 Morrison Road  
Gahanna, OH 43230

Mr. Eithar Nashawati  
Director - Assets Planning  
Oncor Electric Delivery  
2233-B Mountain Creek Parkway  
Dallas TX 75211

Kristian M. Koellner, PE  
Director, Transmission Planning  
Lower Colorado River Authority  
P.O. Box 220  
Austin, TX 78767-0220

RE: Far West Texas Dynamic Reactive Devices and Far West Texas Project 2

On June 12, 2018 the Electric Reliability Council of Texas (ERCOT) Board of Directors endorsed the following Tier 1 transmission project as needed to support the reliability of the ERCOT Regional transmission system:

Far West Texas Dynamic Reactive Devices and Far West Texas Project 2:

- Construct a new approximately 40-mile 345 kV line on double-circuit structures with two circuits in place from Sand Lake 345 kV Switch Station to Solstice 345 kV Switch Station
- Add two new 600 MVA, 345/138 kV autotransformers at Sand Lake 345 kV Switch Station
- Install a new 345 kV circuit on the planned Riverton – Sand Lake double circuit structures
- Install the second 345 kV circuit on the Odessa EHV – Riverton 345 kV line double circuit structures between Moss and Riverton (creating a Moss – Riverton 345 kV circuit)
- Construct a new Quarry Field 138 kV Switch Station in the Wink – Riverton double-circuit 138 kV line
- Construct a new approximately 20-mile Kyle Ranch – Riverton 138 kV line on double-circuit structures with one circuit in place from Kyle Ranch 138 kV Substation to Riverton 138 kV Switch Station

**ATTACHMENT NO. 4**

- Construct a new approximately 20-mile Owl Hills – Tunstill – Riverton 138 kV line on double circuit structures with one circuit in place from Owl Hills 138 kV Switch Substation to Riverton 138 kV Switch Station
- Install the second 345 kV circuit on the planned Solstice Switch Station – Bakersfield Switch Station double circuit structures
- Install one 250 MVAR STATCOM at Horseshoe Springs 138 kV Switch Station
- Install one 250 MVAR STATCOM at Quarry Field 138 kV Switch Station
- Install 150 MVAR static capacitors at Horseshoe Springs 138 kV Switch Station
- Install 150 MVAR static capacitors at Quarry Field 138 kV Switch Station

Further, the Board of Directors designated the Riverton – Sand Lake 345 kV line, the Sand Lake – Solstice 345 kV line, and the Bakersfield – Solstice 345 kV line critical to the reliability of the ERCOT System. Additional details on this project are included in the Attachment A to this letter.

This project was supported throughout the ERCOT planning process, which included participation of all market segments through the ERCOT RPG. ERCOT's recommendation to the Board was reviewed by the ERCOT Regional Planning Group and the ERCOT Technical Advisory Committee (TAC). ERCOT staff looks forward to the successful completion of the work and is ready to assist you with any planning and operations related activities.

Should you have any questions please contact me at any time.

Sincerely,



D. W. Rickerson  
Vice President, Grid Planning and Operations  
Electric Reliability Council of Texas

cc:  
Shawnee Claiborn-Pinto, PUCT  
Bill Magness, ERCOT  
Cheryl Mele, ERCOT  
Warren Lasher, ERCOT  
Jeff Billo, ERCOT  
Prabhu Gnanam, ERCOT

## **Attachment A**





# **ERCOT Independent Review of Oncor Far West Texas Project 2 and Dynamic Reactive Devices**

Version 1.0

## Document Revisions

Date	Version	Description	Author(s)
05/21/2018	1.0	Final Report	Xiaoyu Wang, Ying Li, Priya Ramasubbu
		Reviewed by	Prabhu Gnanam, Shun Hsien (Fred) Huang, Jeff Billo

## Table of Contents

1. Executive Summary .....	1
2. Introduction .....	3
3. Study Assumption and Methodology .....	6
3.1 Study Assumption .....	6
3.2. Criteria for Violations .....	7
3.3. Study Tools .....	8
4. Project Need .....	9
5. Project Options .....	10
5.1. Options Considerations .....	10
5.2. Short-Listed Options .....	10
6. Voltage Stability and Dynamic Stability Analysis .....	12
7. Economic Analysis .....	14
8. Subsynchronous Resonance (SSR) Vulnerability Assessment .....	15
9. Final Options Comparison .....	16
10. Sensitivity Studies .....	17
10.1 Generation Sensitivity Analysis .....	17
10.2. Load Scaling Impact Analysis .....	17
11. Conclusion .....	18
12. Designated Provider of Transmission Facilities .....	19
13. Appendix .....	20

## 1. Executive Summary

In June 2017, the ERCOT Board of Directors endorsed the Far West Texas Project (FWTP), a Tier 1 transmission project to address the transmission needs both in the Culberson Loop area and the Barilla Junction area that could reliably serve the Culberson Loop load up to 717 MW. Since the approval of the FWTP project in 2017, Oncor has confirmed that the Culberson Loop has contractually-confirmed load levels that surpass ERCOT's indicated 717 MW limit for the approved Far West Texas Project. Therefore, the endorsed FWTP project was assumed to be in-service in 2020 for the purpose of this study.

In December, 2017, Oncor submitted the Far West Texas Dynamic Reactive Devices (DRD) Project to the Regional Planning Group (RPG) to meet the summer 2019 Culberson Loop load need. The proposed DRD project was estimated to cost \$86 million and was classified as Tier 1 project. At the time the DRD project was proposed, the Culberson Loop was projected to have 650 MW by 2019 and 790 MW by 2022 with the inclusion of the existing and confirmed load requests in the area.

In February, 2018, Oncor submitted the Far West Texas Project 2 (FWTP2) to address reliability requirements and ensure the transmission system in the area is able to meet the projected contractually-confirmed load level in the Culberson Loop. The proposed FWTP2 project was estimated to cost \$194 million and was classified as a Tier 1 project. At the time the FWTP2 project was proposed, the Culberson Loop was projected to have 775 MW by 2019 and 1013 MW by 2022 with the inclusion of the existing and confirmed load requests in the area.

As of April, 2018, Oncor has confirmed that the Culberson Loop now has contractually-confirmed load levels of 880 MW for 2019 and 1013 MW for 2022. Oncor has also indicated that additional, known potential (not yet contractually-confirmed) load increases in the Culberson Loop may push the total to 1339 MW.

Based on the DRD and FWTP2 proposals, ERCOT completed the combined independent review for both projects together to determine the system needs for both near-term and long-term in a cost effective manner while providing flexibility to meet potential load growth in this region.

Based on the forecasted loads and scenarios analyzed, ERCOT determined that there is a reliability need to improve the transmission system in Far West Texas. After consideration of several project alternatives, ERCOT concluded that the upgrades identified in Option 3 meet the reliability criteria in the most cost effective manner while providing flexibility to accommodate near-term and future load growth in the area of study. Option 3 is estimated to cost \$327.5 million and is described as follows:

- Construct a new approximately 40-mile 345 kV line on double-circuit structures with two circuits in place from Sand Lake Switch Station to Solstice Switch Station
- Add two new 600 MVA, 345/138 kV autotransformers at Sand Lake 345 kV Switch Station
- Install a new 345 kV circuit on the planned Riverton - Sand Lake double circuit structures
- Install the second 345 kV circuit on the Odessa EHV – Riverton 345 kV line double circuit structures between Moss and Riverton (creating a Moss – Riverton 345 kV circuit)
- Construct a new Quarry Field 138 kV Switch Station in the Wink – Riverton double-circuit 138 kV line

- Construct a new approximately 20-mile Kyle Ranch – Riverton 138 kV line on double-circuit structures with one circuit in place from Kyle Ranch 138 kV Switch Station to Riverton 138 kV Switch Station
- Construct a new approximately 20-mile Owl Hills – Tunstill – Riverton 138 kV line on double circuit structures with one circuit in place from Owl Hills 138 kV Switch Station to Riverton 138 kV Switch Station
- Install the second 345 kV circuit on the planned Solstice Switch Station – Bakersfield Switch Station double circuit structures
- Install one 250 MVAR STATCOM at Horseshoe Springs 138 kV Switch Station
- Install one 250 MVAR STATCOM at Quarry Field 138 kV Switch Station
- Install 150 MVAR static capacitors at Horseshoe Springs 138 kV Switch Station.
- Install 150 MVAR static capacitors at Quarry Field 138 kV Switch Station

Reactive support components, including the STATCOMs and capacitors, should be implemented by 2019 if feasible to accommodate the projected 880 MW Culberson Loop demand. Remedial operational schemes may be required in the Culberson Loop area to mitigate post-contingency voltage violations in the near-term until all of the recommended transmission upgrades can be put in-service to meet the Culberson Loop area load growth.

## 2. Introduction

Over the past several years the Far West Texas Weather Zone has experienced high load growth. Between 2010 and 2016 the average annual growth rate was roughly 8%. This strong growth rate was primarily driven by increases in oil and natural gas related demand. Figure 2.1 shows the total projected load (MW) served from the Culberson Loop as indicated in the Oncor's Far West Texas Project 2 (FWTP2) RPG proposal.

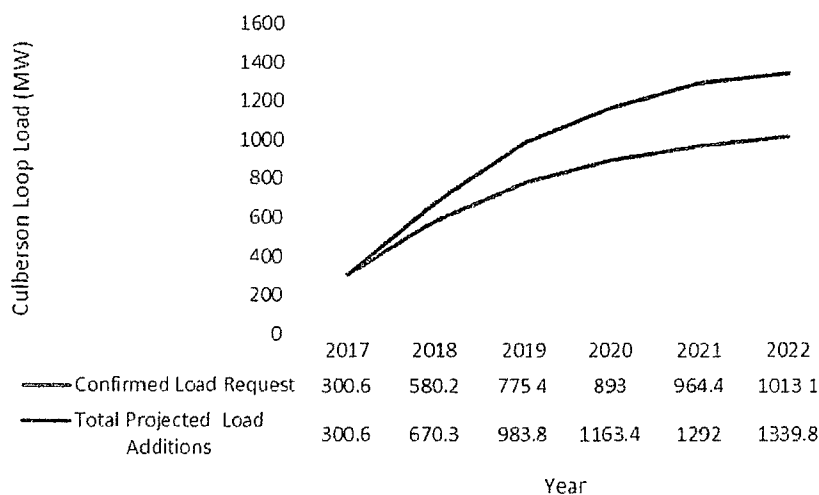


Figure 2.1: Total Projected Load (MW) in the Culberson Loop

Load growth along the Culberson Loop has led to several transmission improvements in the area, including the Far West Texas Project (FWTP) which was endorsed by the ERCOT Board of Directors in June, 2017. The FWTP is expected to be implemented by 2020 and will be able to serve up to 717 MW of Culberson Loop load. Significant new load requests to connect to the Culberson Loop have been observed since the approval of FWTP in 2017 due to growth in the oil and gas activity. As of April, 2018, the Permian Basin oil and natural gas rig count addition by county, as shown in Figure 2.2, has increased by 28% compared to April, 2017. Also, more than 70% of newly added rigs since April, 2017 are located in the counties served by the Culberson Loop transmission system (Culberson, Reeves, Ward, Crane, Loving, and Winkler Counties).

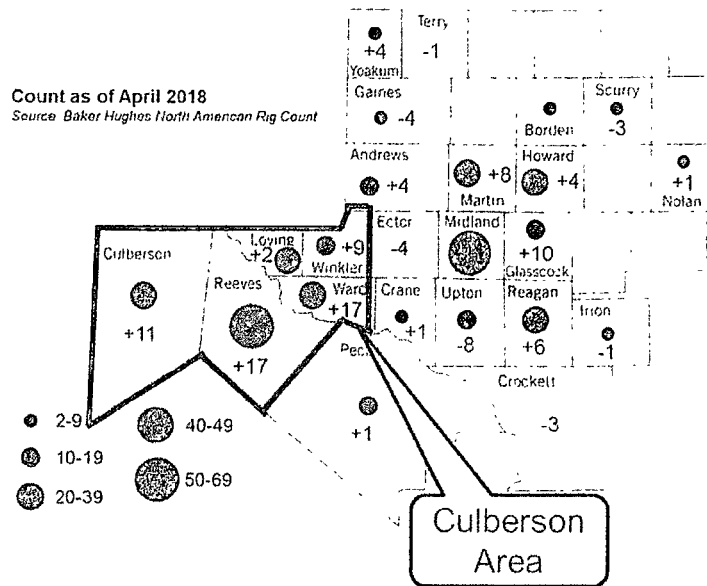


Figure 2.2 Permian Basin Oil and Natural Gas Rig Count Addition since April, 2017

In December, 2017, Oncor submitted to RPG the Far West Texas Dynamic Reactive Devices (DRD) Project, designed to meet the expected summer 2019 Culberson Loop load. The proposed DRD project was estimated to cost \$86 million and was classified as a Tier 1 project. At the time of the DRD project RPG submittal, the Culberson Loop load, with the inclusion of all contractually confirmed load, was projected to be 650 MW by 2019 and 790 MW by 2022. The major components of DRD project proposal were:

- Construct a new Horseshoe Springs 138 kV Switch Station in the Riverton – Culberson 138 kV Double-circuit line
- Install two 250 MVAR, 138 kV Static Synchronous Compensators (STATCOMs) at Horseshoe Spring 138 kV Switch Station

In February 2018, Oncor submitted the Far West Texas Project 2 (FWTP2) to address reliability requirements and ensure the transmission system in the area is able to meet the projected load. The proposed FWTP2 project was estimated to cost \$194 million and was classified as a Tier 1 project. At the time the FWTP2 project was proposed, the Culberson Loop area load, again based on contractually confirmed load requests, was projected to serve 775 MW by 2019 and 1013 MW by 2022. Figure 2.3 shows the proposed FWTP2. The major components of the FWTP2 project proposal include:

- Construct a new approximately 40-mile 345 kV line on double-circuit structures with one circuit in place from Sand Lake 345 kV Switch Station to Solstice 345 kV Switch Station
- Add two new 600 MVA, 345/138 kV autotransformers at Sand Lake 345 kV Switch Station
- Install a new 345 kV circuit on the planned Riverton – Sand Lake double circuit structures
- Install the second 345 kV circuit on the Odessa EHV – Riverton 345 kV line double circuit structures between Moss and Riverton (creating a Moss – Riverton 345 kV circuit)

- Construct a new Quarry Field 138 kV Switch Station in the Wink – Riverton double-circuit 138 kV line
- Construct a new approximately 20-mile Kyle Ranch – Riverton 138 kV line on double-circuit structures with one circuit in place from Kyle Ranch 138 kV Substation to Riverton 138 kV Switch Station
- Construct a new approximately 20-mile Owl Hills – Tunstill – Riverton 138 kV line on double circuit structures with one circuit in place from Owl Hills 138 kV Switch Station to Riverton 138 kV Switch Station

As of April, 2018, Oncor has updated the contractually confirmed Culberson area load to be 880 MW by summer 2019 and 1013 MW by 2022. Additional load requests could potentially push the load to more than 1300 MW in the Culberson Loop.

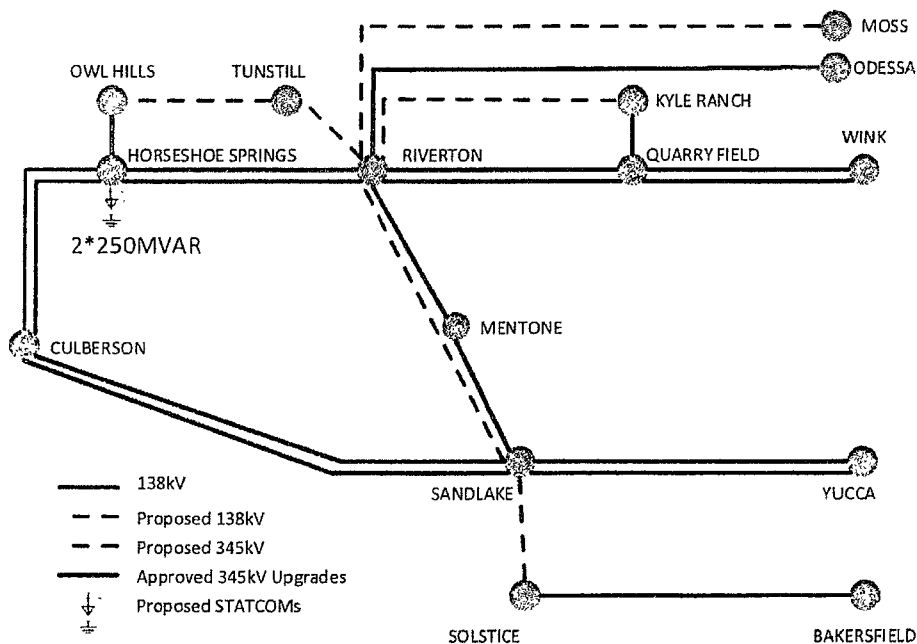


Figure 2.3: Proposed Far West Texas Project 2

Based on both the DRD and the FWTP2 proposals, ERCOT completed this independent review to determine the system needs in the Culberson Loop area and to address those needs in a cost-effective manner while providing the flexibility to meet near-term and potential long-term load growth in this area.

### 3. Study Assumption and Methodology

ERCOT performed studies under various system conditions to evaluate the system need and identify a cost-effective solution to meet those needs in the area. The assumptions and criteria used for this review are described in this section.

#### 3.1. Study Assumption

The primary focus of this review is the Wink – Culberson – Yucca Drive loop transmission system, referred to as the “Culberson Loop.” Figure 3.1 shows the system map of the study area.

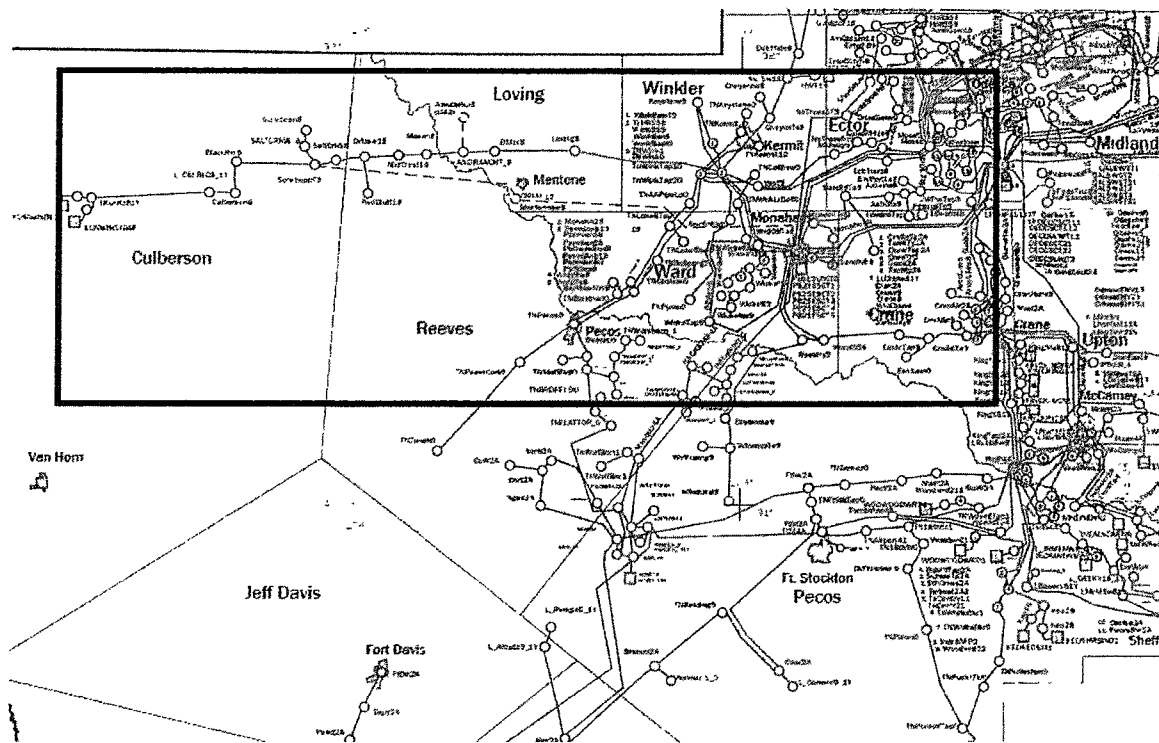


Figure 3.1: Transmission System Map of Study Area

#### Reliability Cases

The following starting cases were used in the study:

- The 2020 West/Far West (WFW) summer peak case from the 2017 RTP reliability case
- The 2020 Dynamics Working Group summer peak flat start case

#### Transmission Topology

The starting case was modified based on input from Oncor to include topological changes, switched shunt additions and load additions in the study area for both near-term 2019 summer peak and 2022 summer peak conditions.

## Study Case Loads and Potential Loads

Oncor provided data regarding increased load projections in the Culberson Loop area. The most recent Oncor submittal data included 880 MW for 2019 summer peak and 1030 MW for 2022 summer peak in the Culberson Loop area. Oncor met with ERCOT and shared information on the signed customer agreements which confirmed these proposed load additions.

Sensitivity cases were also created to reflect higher potential load projections from Oncor. These cases contained additional customer load requests that did not yet have firm commitment at the time of this independent review. To reflect this "Potential" load growth, the load was increased by 334 MW in the Culberson Loop for 2022 summer peak. The total load in the Potential Load Case was approximately 1347 MW in the Culberson Loop for the Potential Load sensitivity.

## Generation

Planned generators in the Far West and West Weather Zones that met Planning Guide Section 6.9 conditions for inclusion in the base cases (according to the 2016 October Generation Interconnection Status report), which were not included in the RTP cases, were added. The added generators are listed in Table 3.1.

**Table 3.1 Added Generators That Met Planning Guide Section 6.9 Conditions (2018 April GIS report)**

GINR Number	Project Name	MW	Fuel	County	Weather Zone
14INR0044	West of Pecos Solar	100	Solar	Reeves	Far West

Key assumptions applied in this study include the following:

- Wind generation in West and Far West weather zones were set to have a maximum dispatch capability of 2.6% of their rated capacity. This assumption was in accordance with the 2016 Regional Transmission Plan Study Scope and Process document<sup>1</sup>.
- Solar generation was set at 70% of their rated capacity in accordance with the 2016 Regional Transmission Plan Study Scope and Process document.
- Considering the oil and gas industry load characteristics (flat load), the most stressed system condition is during the night when solar generation is not available. To study this condition, no solar generation was dispatched in the study base conditions

## Capital Cost Estimates

Capital cost estimates for transmission facilities were provided by Oncor, AEPSC and LCRA TSC. These costs were provided for individual transmission facilities and ERCOT used those values to calculate total project costs for various project options

### 3.2. Criteria for Violations

The following criteria were used to identify planning criteria violations

All 100 kV and above busses, transmission lines, and transformers in the study region were monitored (excluding generator step-up transformers).

- Thermal criteria violations
  - Rate A for Normal Conditions

<sup>1</sup>[http://www.ercot.com/content/wcm/key\\_documents\\_lists/77730/2016\\_RTP\\_Scope\\_Process\\_v1\\_3\\_clean.pdf](http://www.ercot.com/content/wcm/key_documents_lists/77730/2016_RTP_Scope_Process_v1_3_clean.pdf)

- Rate B for Emergency Conditions
- Voltage violation criteria
  - $0.95 < V_{pu} < 1.05$  Normal
  - $0.90 < V_{pu} < 1.05$  Emergency
  - Post Contingency voltage deviations
    - 8% on non-radial load buses
- Dynamic Stability Analysis
  - NERC TPL-001-4 and ERCOT Planning Guide Section 4

### 3.3. Study Tools

ERCOT utilized the following software tools for the independent review of the Far West Texas Project:

- PSS/e version 33 was used to perform the dynamic stability analysis and in the initial steady-state case creation to incorporate the TSP idvs files
- PowerWorld Simulator version 20 for SCOPF and steady state contingency analysis
- VSAT version 17 was used for voltage stability analysis
- UPLAN version 10.2.0.19928

## 4. Project Need

The need for a transmission improvement project was evaluated for the Study Case. Table 4.1 summarized the steady state voltage stability (Power-Voltage) assessment results for the 2019 summer peak. The results showed pre-contingency voltage stability issues with no transmission upgrades. Even with the addition of the ERCOT Board of Directors approved Far West Texas Project (FWTP), as shown in Table 4.1 Scenario 2, the results indicated both voltage violations and voltage collapse under certain contingencies for the projected Culberson Loop 2019 summer peak load. The project need analysis results are consistent with the finding of the 2017 FWTP ERCOT independent review that identified the need for additional upgrades (beyond the FWTP project endorsed in June 2017) to serve loads greater than 717 MW in the Culberson Loop.

**Table 4.1 Steady State Voltage Stability Assessment for the Base Case Condition**

Scenario	Load (MW)	Transmission Upgrades	Culberson Load Serving Capability	
			NERC P1, P7	NERC P6
1.	880 (2019 Summer Peak)	None	Pre-contingency Voltage Collapse	
2.	880 (2019 Summer Peak)	FWTP <sup>(1)</sup>	Voltage Violation Voltage Collapse	Voltage Violation Voltage Collapse

(1) The Far West Texas Project (FWTP) endorsed by ERCOT Board of Directors in June, 2017

## 5. Project Options

### 5.1. Options Considerations

The FWTP, which was endorsed by the ERCOT Board of Directors in June 2017, was designed to allow for a number of different expansion options that could accommodate additional load growth. All project alternatives considered in this study align with the expansion options evaluated as part of the ERCOT FWTP independent review.

In addition, project options considered in this study were limited to alternatives that included adding a second 345 kV circuit to the Odessa EHV – Riverton (between Moss and Riverton) and Solstice – Bakersfield 345 kV lines. This limitation was result of the following considerations:

- The Culberson Loop area has experienced a significant rate of load growth. This evaluation focused on contractually committed load with a sensitivity evaluation which includes new customers that have contacted the TSPs with load requests but have not yet finalized a contract to construct. However, it is possible that more, presently unknown, load requests will materialize before the facilities recommended in this evaluation are in service.
- The Odessa EHV – Riverton and Solstice – Bakersfield 345 kV lines have yet to be constructed. If they were constructed with one circuit in place and a second 345 kV circuit was later deemed necessary, the construction outage to add the second circuit would greatly reduce the load serving capability to the Culberson Loop and reduce the operational flexibility during what would likely be a long duration outage.
- It is approximately 50% less expensive to construct the two circuits in place at the initial build than the cost of coming back to install the second circuit at a later time due to reduced access, environmental and mobilization costs, and construction efficiencies.

In addition, the new 138 kV lines proposed in the FWTP2 project are necessary to strengthen the Culberson Loop and provide operational flexibility under normal and outage conditions.

### 5.2. Short-Listed Options

Based on the considerations listed above and the results of preliminary analysis, the following “universal” transmission upgrades were included in all of the short-listed options:

- Construct a new approximately 40-mile 345 kV line on double-circuit structures with two circuits in place from Sand Lake 345 kV Switch Station to Solstice 345 kV Switch Station
- Add two new 600 MVA, 345/138 kV autotransformers at Sand Lake 345 kV Switch Station
- Install a new 345 kV circuit on the planned Riverton – Sand Lake double circuit structures
- Install the second 345 kV circuit on the Odessa EHV – Riverton 345 kV line double circuit structures between Moss and Riverton (creating a Moss – Riverton 345 kV circuit)
- Construct a new Quarry Field 138 kV Switch Station in the Wink – Riverton double-circuit 138 kV line
- Construct a new approximately 20-mile Kyle Ranch – Riverton 138 kV line on double-circuit structures with one circuit in place from Kyle Ranch 138 kV Substation to Riverton 138 kV Switch Station

- Construct a new approximately 20-mile Owl Hills – Tunstill – Riverton 138 kV line on double circuit structures with one circuit in place from Owl Hills 138 kV Switch Substation to Riverton 138 kV Switch Station
- Install the second 345 kV circuit on the planned Solstice Switch Station – Bakersfield Switch Station double circuit structures

The following three options were studied further for the reactive support in the Culberson Loop. The detailed description of the three short-listed options are provided below and diagrams for these are included in the Appendix.

#### Option 1

- Universal transmission upgrades
- Install two 250 MVAR Static Synchronous Compensators (STATCOMs) at Horseshoe Springs 138 kV Switch Station

The total cost estimate for Option 1 is approximately \$300.0 Million.

#### Option 2

- Universal transmission upgrades
- Install one 250 MVAR Static Synchronous Compensators (STATCOMs) at Horseshoe Springs 138 kV Switch Station
- Install capacitor banks with a total capacity of 150 MVAR at Horseshoe Springs 138 kV Switch Station.
- Install capacitor banks with a total capacity of 150 MVAR at Quarry Field 138 kV Switch Station

The total cost estimate for Option 2 is approximately \$292.5 Million.

#### Option 3

- Universal transmission upgrades
- Install one 250 MVAR Static Synchronous Compensators (STATCOMs) at Horseshoe Springs 138 kV Switch Station
- Install one 250 MVAR Static Synchronous Compensators (STATCOMs) at Quarry Field 138 kV Switch Station
- Install capacitor banks with a total capacity of 150 MVAR at Horseshoe Springs 138 kV Switch Station
- Install capacitor banks with a total capacity of 150 MVAR at Quarry Field 138 kV Switch Station

The total cost estimate for Option 3 is approximately \$327.5 Million.

## 6. Voltage Stability and Dynamic Stability Analysis

A Power-Voltage (PV) analysis was used in the steady state voltage stability assessment for the Culberson Loop area for all short-listed options for the studied scenarios. A Power-Voltage (PV) analysis was used to proportionally increase the load in the Culberson Loop until a voltage collapse identified the maximum load serving capability for the options. Table 7.1 shows the results of this analysis, indicating the maximum loads in the Culberson Loop area that can be reliably served by the three identified project options. A sensitivity analysis was conducted to evaluate the impact of nearby generators to the Culberson Loop load serving capability. All five generators at the Permian Basin (PBSES) generation station were off-line in the study case. The PV results are listed in Table 7.1

**Table 7.1 Voltage and Dynamic Stability Assessment of All Options for Culberson Loop Load Serving Capability**

Description	Culberson Loop Load Served (MW)		
	Option 1	Option 2	Option 3
PV Voltage Collapse Results (NERC P1, P6, P7, ERCOT Events)	1608	1568	1688
PV Voltage Collapse Results (without PBSES Units) (NERC P1, P6, P7, ERCOT Events)	1508	1468	1648
Dynamic Stability Result (without PBSES Units) (NERC P1, P6, P7, ERCOT Events) <sup>(1)</sup>	Acceptable	Acceptable	Acceptable
Estimated Capital Cost (\$M)	300	292.5	327.5

(1) Dynamic stability was conducted at the Culberson Loop load level identified in the PV voltage collapse results

The majority of the loads in the study area were assumed to be oil and gas customers who employ voltage-sensitive electric equipment in their operations. As specified by Oncor, heavy motor load was assumed to represent the load characteristic in the study area. All three options were tested using time domain dynamic stability simulations including a dynamic load model provided by Oncor to evaluate system stability.

It was assumed that if simulations indicated an acceptable (stable) system response following severe events and/or three-phase faults, the stability response would also be acceptable for the same events with a single-line-to-ground (SLG) fault. If a potential stability issue was observed, the simulation was rerun with SLG faults to ensure a stable system response following a NERC planning event. In this way the analysis demonstrated compliance with NERC planning standards and ERCOT reliability criteria. In these simulations, selected ERCOT transmission buses were monitored for angle and voltage responses.

The dynamic event definitions included the removal of all elements that the protection system and other automatic controls are expected to disconnect for each event. The dynamic simulation results are also listed in Table 7.1.

None of the three options will be fully in-service prior to summer 2019, when the load is projected to reach 880 MW, since the new transmission lines will not be constructed. As a result, a PV analysis was conducted for the 2019 summer condition assuming only the reactive devices in all three options can be implemented to support the Culberson Loop in 2019. The PV analysis results are listed in Table 7.2. The results indicate that for Options 1 and 2 additional operational mitigation measures will be needed to maintain reliability prior to the new transmission lines being put in place. These operational mitigation measures may include (but are not limited to) undervoltage load shed.

**Table 7.2 Steady State Voltage Stability Assessment of All Options for Culberson Loop Load Serving Capability with Reactive Devices Only**

Description	Culberson Loop Load Served (MW)		
	Option 1	Option 2	Option 3
PV Voltage Collapse Results (reactive devices only) <sup>(1)</sup> (NERC P1, P6, P7, ERCOT Events)	801	821	1001
PV Voltage Collapse Results (without PBSES units) (reactive devices only) <sup>(1)</sup> (NERC P1, P6, P7, ERCOT Events)	721	741	880 <sup>(2)</sup>

(1). Assuming reactive devices will be in service before new transmission lines

(2) Oncor indicated that the reactive devices identified to be located at Quarry Field 138 kV Switch Station may not be in service by summer 2019. ERCOT performed a PV analysis considering only the reactive devices located at Horseshoe Springs from Option 3. The results showed that without the Quarry Field reactive devices in service, Option 3 would have a load serving capability of 721 MW.

## **7. Economic Analysis**

Although this RPG project is driven by reliability needs, ERCOT also conducted an economic analysis to identify any potential impact on system congestion related to the addition of the transmission upgrades.

The base case for this economic analysis used the 2023 economic case built for the 2017 RTP as the starting case. The topology changes and generation additions were similar to the steady state base case built. ERCOT modeled each of the three short-listed options and performed production cost simulations for the year 2023. The annual production analysis showed no measurable congestion impact on the ERCOT System with the addition of the transmission upgrades.

## **8. Subsynchronous Resonance (SSR) Vulnerability Assessment**

According to Protocol Section 3.22.1.3(2), ERCOT performed a SSR vulnerability assessment using topology check and the results indicated that all three short-listed options strengthen the transmission network and increase the required transmission circuit outages to have a Generation Resource become radial to series capacitors. The SSR assessment results showed no SSR vulnerability for any existing Generation Resources or Generation Resources satisfying Planning Guide Section 6.9 conditions for inclusion in the planning models at the time of this study.

## 9. Final Options Comparison

As shown in Table 9.1, a comparison of study results for the three options shows that Option 3, shown in Figure 9.1, met the system reliability criteria under the studied load conditions while providing better load serving capability to accommodate both the near-term and potential future load needs in the Culberson Loop area.

Table 9.1 Options Comparison

Description	Option 1	Option 2	Option 3
Capital cost (\$ Million)	300.0	292.5	327.5
PV Results, Culberson Load Served	1608	1568	1688
PV Results, Culberson Load Served (with only reactive support devices recommended in the options)	801	821	1001
PV Results, Culberson Load Served (without PBSES Units)	1508	1468	1648
PV Results, Culberson Load Served (without PBSES Units) (with only reactive support devices recommended in the options)	721	741	880
Dynamic Stability Results, Culberson Load Served	Acceptable	Acceptable	Acceptable

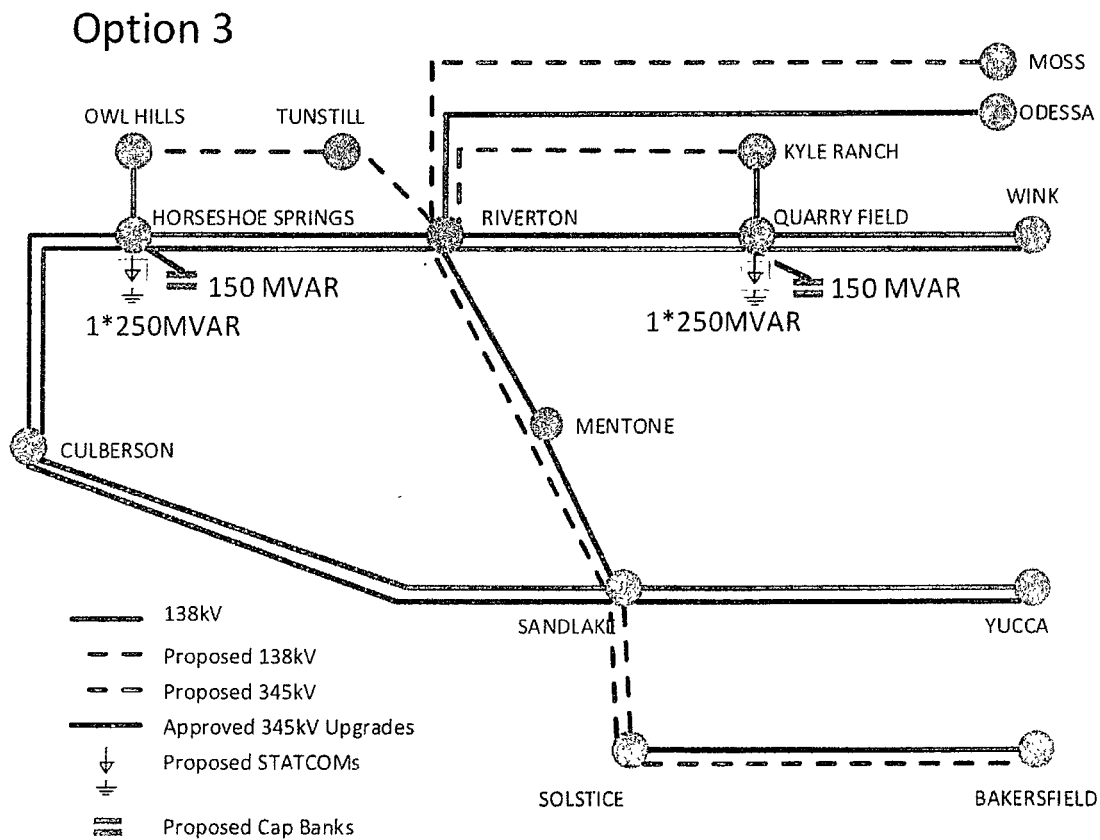


Figure 9.1: Option 3

## 10. Sensitivity Studies

Sensitivity studies were performed to ensure compliance with Planning Guide requirements.

### 10.1. Generation Sensitivity Analysis

According to Planning Guide Section 3.1.3(4)(a), the generation sensitivity analysis will evaluate the effect that proposed Generation Resources in or near the study area will have on a recommended transmission project. Based on the 2018 April Generator Interconnection Status report, Table 10.1.1 shows all the generators in the area that met Planning Guide 6.9 and Table 10.1.2 shows all the generators in the area with a signed standard generator interconnection agreement (SGIA) that did not meet Planning Guide 6.9 conditions for inclusion in the planning models. Considering the oil and gas industry load characteristics, the most stressed system condition is during the night when solar generation is not available. No solar generation in the Culberson Loop was assumed available in the study base conditions. Therefore, the proposed Generation Resources in the Culberson Loop area will have no impact on the recommended transmission project.

**Table 10.1.1 Generators Met Planning Guide Section 6.9 Conditions (2017 March GIS report)**

GINR Number	Project Name	MW	Fuel	County	Weather Zone
14INR0044	West of Pecos Solar	100	Solar	Reeves	Far West

**Table 10.1.2 Generators with SGIA That Did Not Meet Planning Guide Section 6.9 Conditions (2017 March GIS report)**

GINR Number	Project Name	MW	Fuel	County	Weather Zone
18INR0022	Winkler Solar	150	Solar	Winkler	Far West

### 10.2. Load Scaling Impact Analysis

Planning Guide Section 3.1.3(4) (b) requires evaluation of the impact of various load scaling on the criteria violations seen in the study cases.

Because the voltage violations were observed at load serving buses inside the Culberson Loop, ERCOT assumed that the load scaling in the outside weather zones did not have a material impact on the observed need.

## 11. Conclusion

Based on the forecasted loads and scenarios analyzed, ERCOT determined that there is a reliability need to improve the transmission system in Far West Texas. After consideration of the project alternatives, ERCOT concluded that the upgrades identified in Option 3 meet the reliability criteria in the most cost effective manner and provide needed load serving capability to the rapid oil and gas industry load growth in the Culberson Loop area. Option 3 is estimated to cost \$327.5 million and is described as follows:

- Construct a new approximately 40-mile 345 kV line on double-circuit structures with two circuits in place from Sand Lake 345 kV Switch Station to Solstice 345 kV Switch Station
- Add two new 600 MVA, 345/138 kV autotransformers at Sand Lake 345 kV Switch Station
- Install a new 345 kV circuit on the planned Riverton – Sand Lake double circuit structures
- Install the second 345 kV circuit on the Odessa EHV – Riverton 345 kV line double circuit structures between Moss and Riverton (creating a Moss – Riverton 345 kV circuit)
- Construct a new Quarry Field 138 kV Switch Station in the Wink – Riverton double-circuit 138 kV line
- Construct a new approximately 20-mile Kyle Ranch – Riverton 138 kV line on double-circuit structures with one circuit in place from Kyle Ranch 138 kV Substation to Riverton 138 kV Switch Station
- Construct a new approximately 20-mile Owl Hills – Tunstill – Riverton 138 kV line on double circuit structures with one circuit in place from Owl Hills 138 kV Switch Substation to Riverton 138 kV Switch Station
- Install the second 345 kV circuit on the planned Solstice 345 kV Switch Station – Bakersfield 345 kV Switch Station double circuit structures
- Install one 250 MVAR STATCOM at Horseshoe Springs 138 kV Switch Station
- Install one 250 MVAR STATCOM at Quarry Field 138 kV Switch Station
- Install 150 MVAR static capacitors at Horseshoe Springs 138 kV Switch Station
- Install 150 MVAR static capacitors at Quarry Field 138 kV Switch Station

The reactive support components, including STATCOMs and capacitors, recommended in Option 3 should be implemented by 2019 if feasible to accommodate the projected 880 MW Culberson Loop in summer 2019. Additionally, the sizing of capacitor bank stages should take into account operational considerations. Remedial operational schemes may be required to mitigate post-contingency voltage violations in the Culberson Loop area until the recommended transmission upgrades can be built to reliably serve the increasing load.

## 12. Designated Provider of Transmission Facilities

In accordance with the ERCOT Nodal Protocols Section 3.11.4.8, ERCOT staff is to designate transmission providers for projects reviewed in the RPG. The default providers will be those that own the end points of the new projects. These providers can agree to provide or delegate the new facilities or inform ERCOT if they do not elect to provide them. If different providers own the two ends of the recommended projects, ERCOT will designate them as co-providers and they can decide between themselves what parts of the recommended projects they will each provide.

Oncor owns the Odessa EHV Switch Station, Moss Switch Station and is planning to construct and own the new Riverton Switching Station and therefore is the presumed owner of the Riverton Switching Station. Therefore, ERCOT designates Oncor as the designated provider for the 345 kV Odessa EHV to Riverton and Moss to Riverton transmission facilities along with the two recommended 345/138 kV autotransformers at Riverton.


LCRA TSC owns the Bakersfield Switchyard while AEPSC is constructing and planning to own the new Solstice Substation and therefore is the presumed owner of the Solstice Substation. Therefore, ERCOT designates AEPSC and LCRA TSC as the designated co-providers for the 345 kV Bakersfield to Solstice transmission facilities but AEPSC as the provider of the two recommended 345/138 kV autotransformers at Solstice.

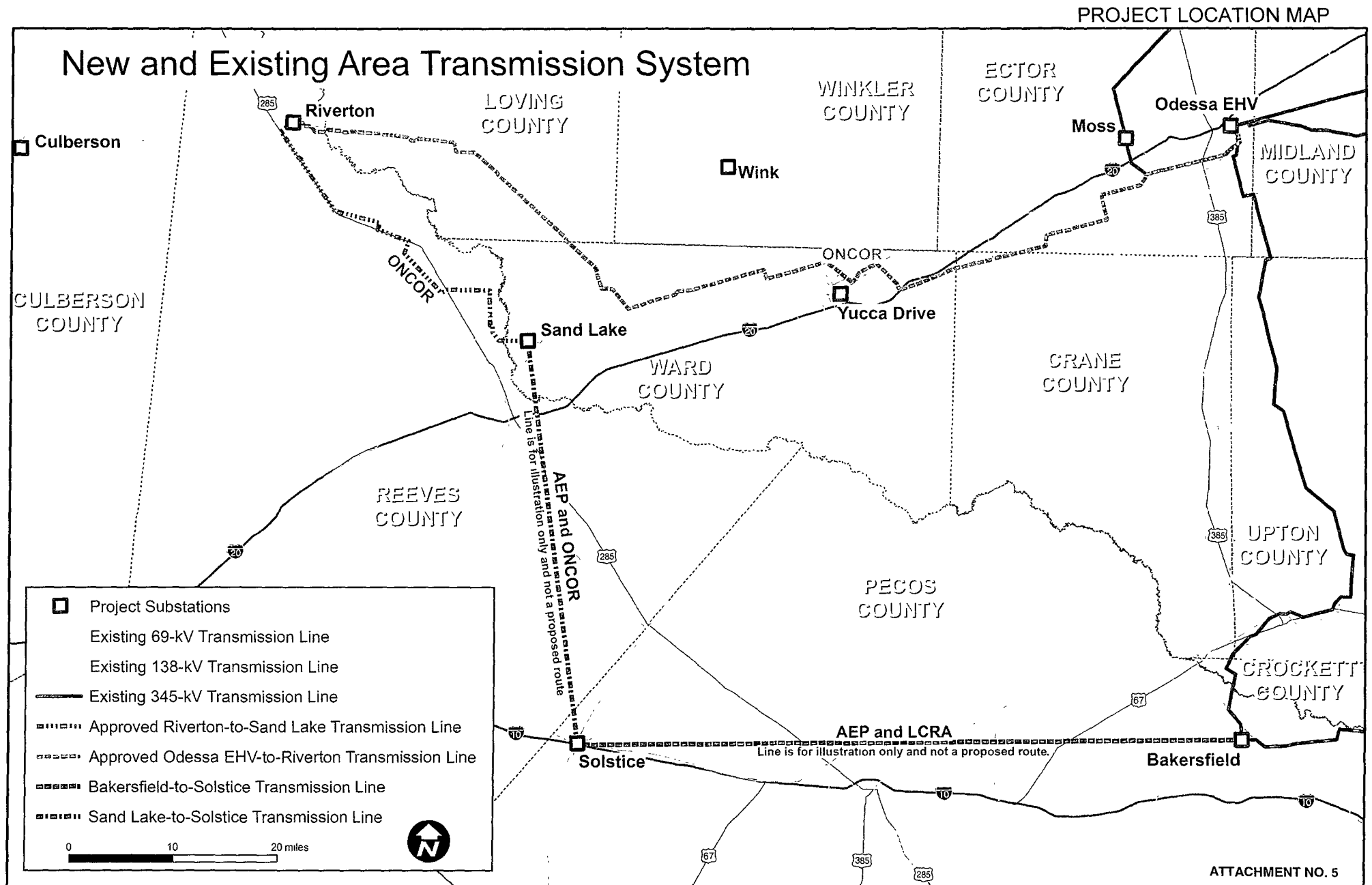
Oncor is planning to construct and own the new Sand Lake Switching Station and therefore is the presumed owner of the Sand Lake Switching Station, while AEPSC is constructing and planning to own the new Solstice Substation and therefore is the presumed owner of the Solstice Substation. ERCOT designates Oncor and AEPSC as the designated co-providers for the 345 kV Sand Lake to Solstice transmission facilities and Oncor as the provider of the two recommended 345/138 kV autotransformers at Sand Lake Switch Station.

Oncor owns all the 138 kV Switch Stations listed in the recommended Option 3. Therefore, ERCOT designates Oncor as the designated provider for all the 138 kV transmission facilities along with the proposed STATCOMs and static capacitor banks.

The designated TSPs have requested critical designation status for the Riverton – Sand Lake 345 kV Line, the Sand Lake – Solstice 345 kV Line, and the Bakersfield – Solstice 345 kV line for multiple operational and reliability needs to address the rapid load growth in the Culberson Loop area. ERCOT designates the project critical to reliability per PUCT Substantive Rule 25.101(b)(3)(D).

13. Appendix

Options Diagrams	 Options_OneLine.p ptx
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# FAR WEST TEXAS PROJECT

ERCOT REGIONAL PLANNING GROUP PROJECT SUBMITTAL FOR REVIEW

April 20, 2016

AMERICAN ELECTRIC POWER SERVICE CORPORATION  
ONCOR ELECTRIC DELIVERY COMPANY CO LLC



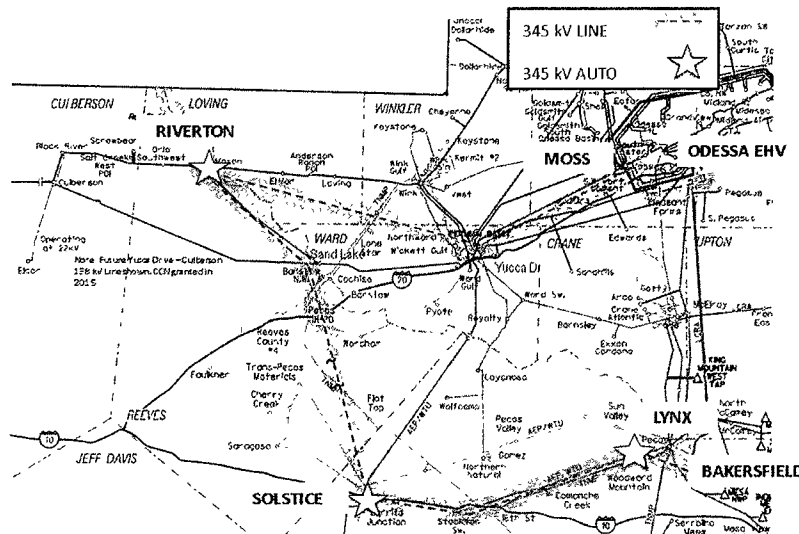
ATTACHMENT NO. 6

# Table of Contents

<b>EXECUTIVE SUMMARY .....</b>	<b>3</b>
<b>INTRODUCTION.....</b>	<b>4</b>
<b>PURPOSE AND NECESSITY .....</b>	<b>6</b>
<i>Load Growth .....</i>	<i>6</i>
<i>Generation Growth.....</i>	<i>8</i>
<i>Oncor Studies.....</i>	<i>10</i>
<i>ERCOT Studies.....</i>	<i>14</i>
<i>AEP Studies.....</i>	<i>14</i>
<i>Short Circuit Strength .....</i>	<i>16</i>
<i>High Voltage Points-of-Delivery (PODs).....</i>	<i>18</i>
<i>TSP Point-of-Interconnections .....</i>	<i>18</i>
<i>Operational Flexibility.....</i>	<i>19</i>
<i>Region Long Term Upgrade Path.....</i>	<i>19</i>
<b>PROJECT DESCRIPTION .....</b>	<b>20</b>
<i>Odessa EHV – Riverton 345 kV Line (Oncor) .....</i>	<i>20</i>
<i>Riverton Switching Station (Oncor) .....</i>	<i>20</i>
<i>Solstice 345 kV Switching Station (AEP) .....</i>	<i>20</i>
<i>Riverton – Solstice 345 kV Line (AEP &amp; Oncor) .....</i>	<i>20</i>
<i>Lynx 345 kV Switching Station (AEP) .....</i>	<i>20</i>
<i>Solstice – Lynx 345 kV Line (AEP).....</i>	<i>20</i>
<i>Lynx – Bakersfield 345 kV Line (AEP) .....</i>	<i>21</i>
<b>PROJECT COSTS .....</b>	<b>21</b>
<b>ONE-LINE DIAGRAM.....</b>	<b>23</b>
<b>ALTERNATIVE PROJECTS.....</b>	<b>24</b>
<i>Alternative - Dynamic Reactive Device(s), 138 kV, and 69 kV Upgrades .....</i>	<i>24</i>
<b>CONCLUSION .....</b>	<b>28</b>

## Executive Summary

This report describes the purpose and necessity to construct the Far West Texas Project (FWTP). The FWTP consists of a 345 kV line from Odessa to Moss to Permian Basin to Mason to Pecos to Barrilla to Fort Stockton to Rio Pecos to Bakersfield; with the initial installation of 345/138 kV autotransformers at Riverton, Solstice and Lynx stations. The estimated total cost of the project is \$423 million with an in-service date of 2022 or sooner. It also provides for longer term growth in the Region by allowing for the future addition of a second 345 kV circuit and additional autotransformer installations. This is a joint project of American Electric Power Service Corporation (AEP) and Oncor Electric Delivery Co LLC (Oncor). We are requesting that ERCOT and the Regional Planning Group (RPG) consider and review this proposed project to address transmission constraints and needs.



AEP and Oncor continue to monitor West Texas load growth due to oil and natural gas production, transportation, mid-stream processing, and associated support activities in the Permian Basin. The Delaware Basin remains very active and significant load growth is resulting in the need for the addition of new transmission infrastructure in areas where little existed previously.

Additionally, AEP and Oncor continue to monitor new generation interconnection requests in the region. The Barrilla Junction Area southwest of Odessa remains very active with solar generation developments that will require additional transmission capacity and support.

The Far West Texas Project is needed to:

- Provide reliable service to current and future load
- Relieve planning criteria violations including overloading and voltage collapse with loss of load
- Support continuing oil/natural gas load growth and new generation interconnections
- Provide injection sources to aid short circuit strength limitations and meet system protection requirements
- Increase transmission operational flexibility under various normal and contingency conditions
- Provide a path for long-term upgrades to the region

AEP and Oncor are proposing and seeking endorsement of the FWTP which is proposed to be fully completed by 2021 to 2022. This date may change based on uncertainty in the timing of certification, environmental assessment, land acquisition, critical project status and/or other requirements.

## Introduction

This report describes the need to construct the approximately 219-mile Far West Texas Project (FWTP) in Ector, Reeves, Pecos, Ward, and Winkler Counties.

The need to expand transmission facilities in West Texas is driven by increasing load due to the oil and natural gas industry and by solar generation development. Horizontal drilling technology has expanded production in the Permian Basin and resulted in increased electric demand to meet the requirements of oil and natural gas field operations, mid-stream processing, and a growing local economy. Much of this activity focuses on one of the largest reservoirs known as the Delaware Basin, and shown below in Figure 1.

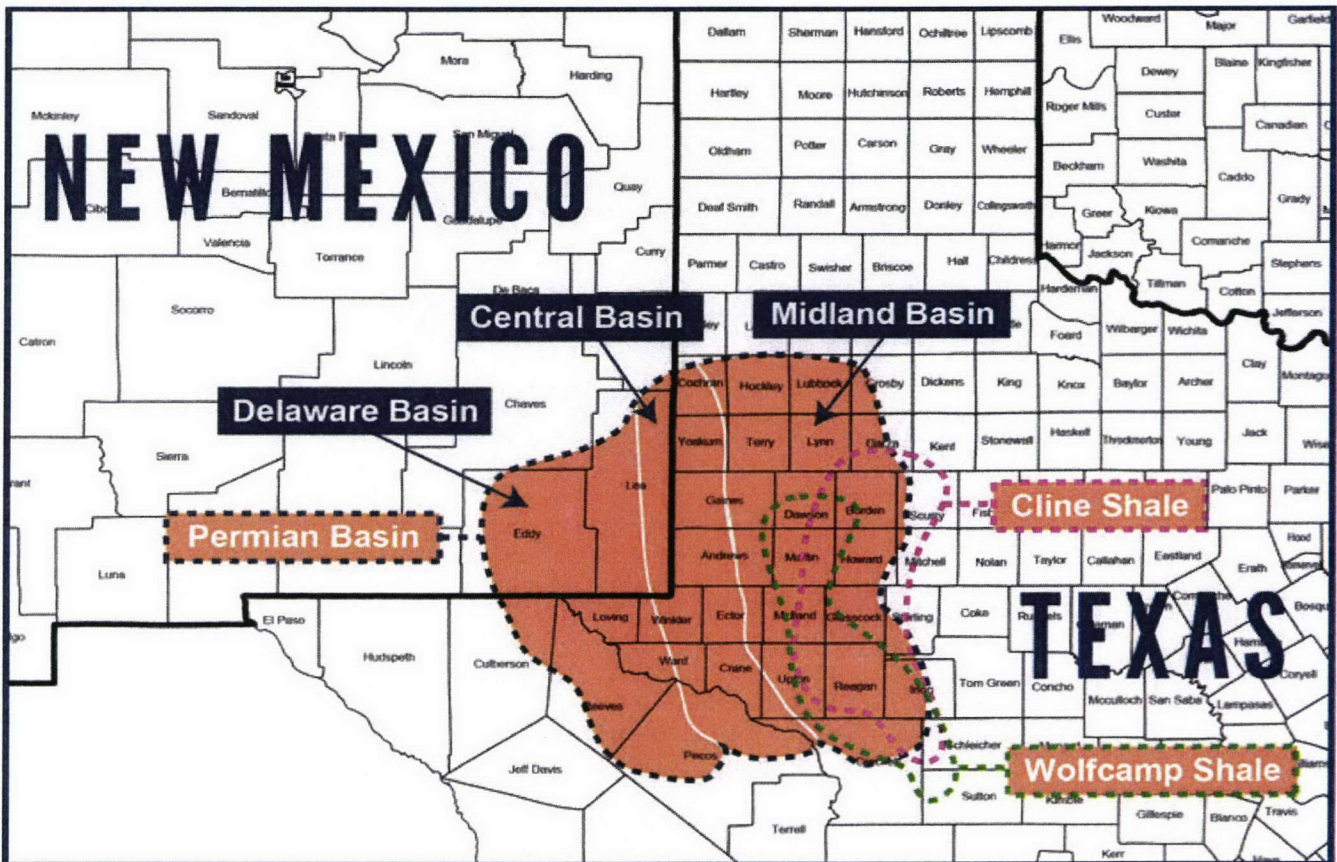


Figure 1 – Location of Delaware Basin

The loads in the Delaware Basin area are served by three Transmission Service Providers (TSPs) including Oncor, AEP, and Texas New Mexico Power (TNMP). All TSPs continue to support this growth with local area projects including the upgrade of existing transmission lines, installation of new and upgraded autotransformers, the conversion of the 69 kV system to a stronger 138 kV service, the installation of reactive devices, and the addition of substation capacity.

Oncor recently completed rebuilding the 138 kV line sections between Mason Substation and Screwbean Substation, which is part of a 74-mile radial line that extends from the Wink Switching Station (Sw. Sta.) to the Culberson 138 kV Sw. Sta. in Culberson County. The remaining 138 kV line section between Screwbean Substation

and Culberson is planned for reconstruction by the end of 2017. Oncor will also begin construction on the new Yucca Drive – Culberson 138 kV Line in 2016. Yucca Drive is a new switching station near the Permian Basin Sw. Sta. located in Ward County. The new line will complete a 138 kV loop from Wink to Culberson and back to Yucca Drive (The Wink – Culberson – Yucca Drive Loop). In support of this Loop, Oncor recently submitted the new Riverton – Sand Lake 138 kV Line proposal to the ERCOT RPG.

AEP and Oncor also recently submitted the Barrilla Junction Area Improvement Project proposal to the ERCOT RPG, which includes rebuilding the Yucca Drive – Barrilla Junction 138 kV Line. The area southwest of Odessa, served by the 69 kV and 138 kV lines between Permian Basin, Barrilla Junction, Fort Stockton Plant, and Rio Pecos stations (The Barrilla Junction Area) has seen an increased interest in solar generation development.

While these previously submitted projects are effective in addressing local issues, they provide limited improvement on a larger scale and do not provide a new transmission source, a 345 kV source, to satisfy the growing load and the interconnection needs of new generation in the Far West Texas area. Both the previously submitted 138 kV projects and the FWTP needed as part of the long-term plan in West Texas .

The location of the FWTP and surrounding transmission system is shown below in Figure 2. The respective areas of The Wink – Culberson – Yucca Drive Loop and The Barrilla Junction Area are shown within the blue circles.

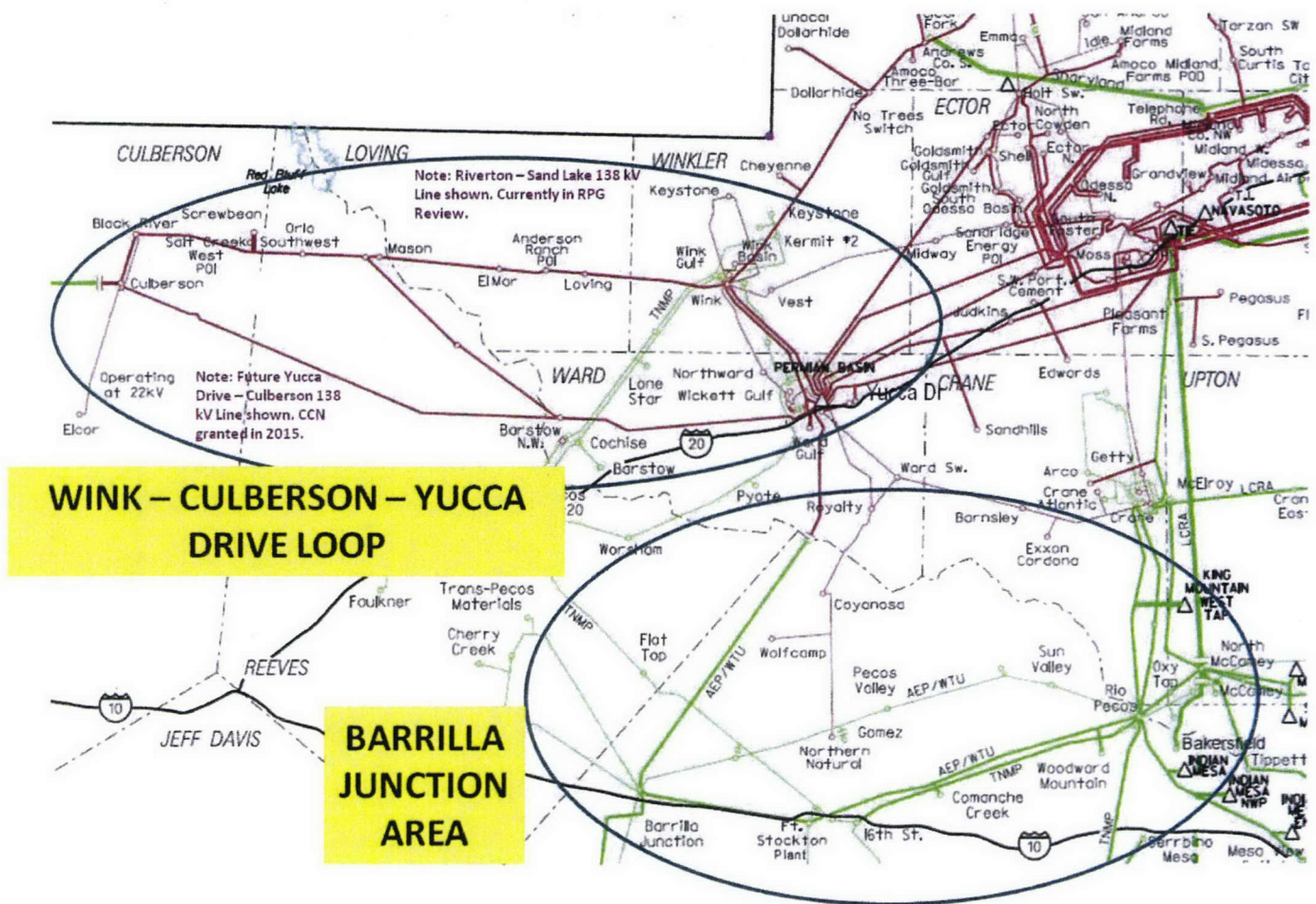


Figure 2 – Location of the Far West Texas Project

## Purpose and Necessity

### Load Growth

The electric load in West Texas has grown dramatically over the last several years. This load growth is continuing due to the oil/natural gas industry and supporting businesses. Recent improvements in oil and natural gas horizontal drilling technologies have increased activity in the area, resulting in major load growth at existing substations and the need for new substations to serve the added load in Far West Texas. Despite declining oil prices over the last 18-24 months, AEP and Oncor have continued to experience increased loads in this area compared to historical load levels. This increase in oil and natural gas production, transportation and mid-stream processing has resulted in economic growth in the area that is supporting the industry. Figure 3 below shows the growing load in the area despite a production drawback in the Permian Basin.

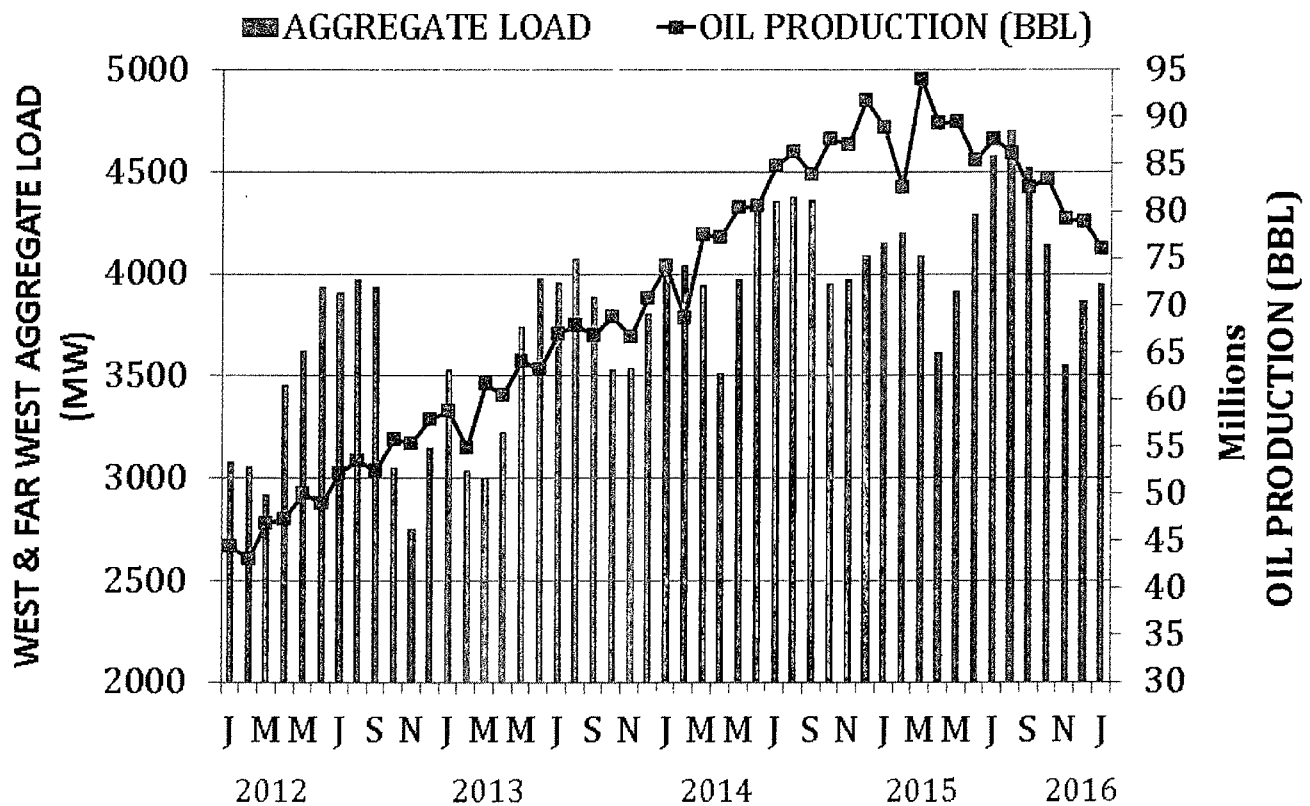


Figure 3 – Growing Aggregate Load vs. Oil Production

While the oil and natural gas production levels have recently leveled, the business friendly environment of Texas, existing infrastructure, and the geological characteristics of the Permian Basin make it a prime candidate to be the first oil and natural gas area that returns to high growth levels. Additionally, developing improvements in horizontal drilling technologies are resulting in improvements in efficiencies, speed, and service cost reductions which will only improve horizontal well margins and economics as time progresses. More background info and data is available from the link below for the “Oil and Gas Seminar – An Education on the Permian Basin Production and Processing Techniques” held November 10, 2015 at ERCOT in Austin, TX.

<http://www.ercot.com/calendar/2015/11/10/76898-WORKSHOPS>

Secondary facilities that follow and support production, including midstream processing plants, also create a challenge for area TSPs as they are large amounts or “blocks” of load, sometimes 40 to 100 MW located 50 to 100 miles apart. The inherent nature of midstream facilities results in wide variations in electrical power needs and geography, allowing for little predictability or transparency into exact locations for these developments, other than being regionally located with production fields. The need for transmission facilities to adequately serve these types of midstream facilities is critical since such large loads can have large, stressing impacts on transmission system capacity and voltage.

The FWTP is located in the Delaware Basin, a highly active area for drilling for oil and natural gas in the western portion of the Permian Basin. The electrical summer peak load for Oncor counties within the Delaware Basin, including Culberson, Reeves, Loving, Ward and Winkler Counties grew at an annual rate of approximately 13% from 2012 to 2015. Oncor’s expected annual growth for the area will average 11% over the next five years and 7.0% over the next 10 years.

The table below shows the sum of historical and projected summer peak loads (MW) for The Wink – Culberson – Yucca Drive Loop. The loads from 2010 to 2015 are actual summer peaks (MW), and the loads for 2016 to 2021 are projected summer peaks (MW) from the 2016 Annual Load Data Request (ALDR). These projections only include confirmed load increases from normal load forecasting and signed customer agreements. There are other active inquiries to connect additional customers in the area, but the load associated with these requests has not been included in Table 1.

	Historical Load						Projected Load					
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total (MW)	22.4	21.6	33.4	53.2	89.7	105.4	231	304	343	391	411	426

Table 1- Historical and Projected Load (MW) Served from the Wink – Culberson – Yucca Drive Loop

Currently AEP projects over 350 MW of summer peak load for The Barrilla Junction Area. With the oil and natural gas activity in the area, AEP anticipates that The Barrilla Junction Area load will grow to over 500 MW by 2021 with over 160 MW being served by the Yucca Drive – Barrilla Junction 138 kV Line alone. Table 2 below shows the sum of projected summer peak loads (MW) being served by the Barrilla Junction Area transmission lines.

	2016	2017	2018	2019	2020	2021
Total (MW)	387	454	483	487	490	511

Table 2- Projected Load (MW) Served from the Barrilla Junction Area Lines

Oncor studies have shown that as load increases in the Delaware Basin on The Wink – Culberson – Yucca Drive Loop, additional projects will be needed to adequately serve the load. AEP studies have shown that after the Barrilla Improvement Transmission Project, additional thermal issues will exist on the two 138 kV paths between Barrilla Junction/Solstice and Rio Pecos. Additional transmission infrastructure improvements will be needed to reliably serve growing load in the region.

## Generation Growth

The Barrilla Junction Area is under increased interest for solar generation development. As of April 2016, more than 7,700 MW of solar development projects are currently in the ERCOT generation interconnection process, most of which are concentrated in the West and Far West weather zones of West Texas where transmission infrastructure is either relatively weak or no infrastructure exists.

Currently there is over 1,650 MW of renewable generation in The Barrilla Junction Area including a 160 MW wind facility (Woodward Mountain) that is interconnected west of Rio Pecos. There is approximately 850 MW of conventional generation north of the Barrilla Junction Area at Permian Basin SES, Odessa Ector, and Quail. Figure 4 below shows The Barrilla Junction Area and surrounding generation.

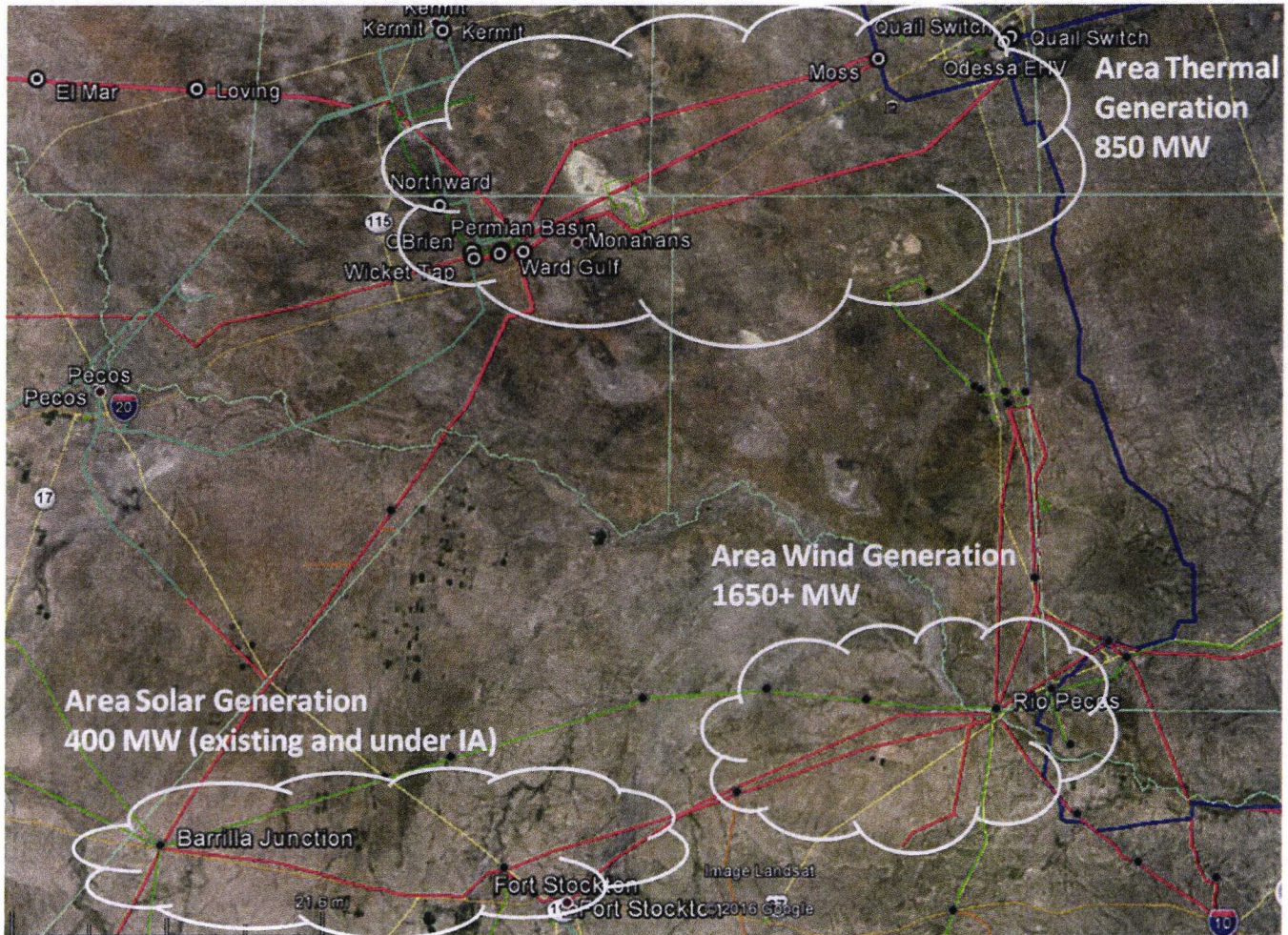


Figure 4- Barrilla Junction Area and Surrounding Generation

Both AEP and Oncor have received multiple inquiries for generation interconnects in the region. Based on the March 2016 ERCOT Transmission Generation Interconnect Project list, there are 27 projects in the planned status in the FWTP's surrounding counties of Culberson, Pecos, Reeves, and Winkler counties totaling 3,380 MW of new generation. New solar generation developments account for 25 of the 27 projects.

Oncor has 5 requests in the study queue for generation interconnects in the FWTP's surrounding area, totaling 758 MW of new generation. New solar generators represent 4 of the 5 requests, totaling 635 MW.

AEP has approximately 1,000 MW in signed interconnect agreements (IAs) with solar generators that are connecting in Pecos, Reeves, and Upton counties with approximately 400 MW connecting directly on the 138 kV and 69 kV transmission system in the Barrilla Junction Area. In addition, AEP has an additional 1,000 MWs of generation in the study queue.

The solar generation facilities in The Barrilla Junction Area include:

- Barrilla Solar (50 MW) located just west of the existing Barrilla Junction 138 kV Station
- Rose Rock (150 MW) that has an executed IA and is under construction which will interconnect at the Barrilla Junction/Solstice Station
- Oak Solar (150 MW) that has an executed IA and will be connected to the Fort Stockton Plant 138 kV Station
- Solaire Holman (50 MW) that has an executed IA and will be connected to the Ft. Stockton Plant – Alpine 69 kV Line
- East Pecos Solar (120 MW) that has an executed IA and will be connected at Bakersfield 345 kV Station
- Maplewood Solar (500 MW) that has an executed IA and will be connected at Bakersfield 345 kV Station

AEP studies indicate that the transmission lines in The Barrilla Junction Area will be close to their maximum transfer capability with the interconnection of these future solar generation facilities. As a result, transmission infrastructure improvements will be needed in the region to support future solar development. With Federal Investment Tax Credits extended, solar and other renewable generation developments in the area are expected to continue.

The Far West Texas Project satisfies existing and anticipated reliability needs, creates new pathways for new generation to access the 345 kV transmission system, increases transfer capacity, and enables reliable transfer to load centers. Completion of the FWTP also provides greater flexibility in conventional generation dispatch, which should help address congestion in the area.

## Oncor Studies

Oncor studies identified certain outages on The Wink – Culberson – Yucca Drive Loop that result in unacceptable system conditions. The worst contingency in this region is loss of the Wink – Loving 138 kV line section, which causes the remaining line sections looking toward Culberson and Yucca Drive to be insufficient to maintain adequate system operating conditions, resulting in an unsolved contingency during power flow analysis. The unsolved contingency shows an inability of the power system to maintain stable bus voltages following a disturbance or deviation from its initial operating condition. These unacceptable voltage conditions in the area will increase as load on The Wink – Culberson – Yucca Drive Loop rises to even higher levels.

Upon seeing these issues, Oncor began development and completion of several projects in the area. In addition to completing the rebuild of the existing Wink – Culberson 138 kV Line, Oncor has plans to install a shunt capacitor at Castile Hills and install second circuits on both the Wink – Culberson and the new Yucca Drive – Culberson 138 kV lines. In addition to installing double-circuits on The Wink – Culberson – Yucca Drive Loop, Oncor will relocate some substations onto the new second circuits in order to help voltage regulation and further diversify line loading. Support is also provided by the addition of the Riverton – Sand Lake 138 kV Line currently under review by the ERCOT RPG.

While these projects would initially help support system voltages pre- and post-contingency, additional voltage support will be needed in the area as the load continues to grow. Dynamic stability studies indicate additional improvements are needed in the area in order to support system voltage levels and increase system strength.

Below in Figure 5, the worst single-circuit branch outage voltage plot is shown with all the previously mentioned projects in place. The Wink – Culberson – Yucca Drive Loop voltage response is able to stabilize to acceptable levels, however delayed voltage recovery is evident, which could cause problems for customer load, particularly those of oil and natural gas customers. The simulation assumed heavy motor load, typical of oil and natural gas load in the area, using a 2019 base case.

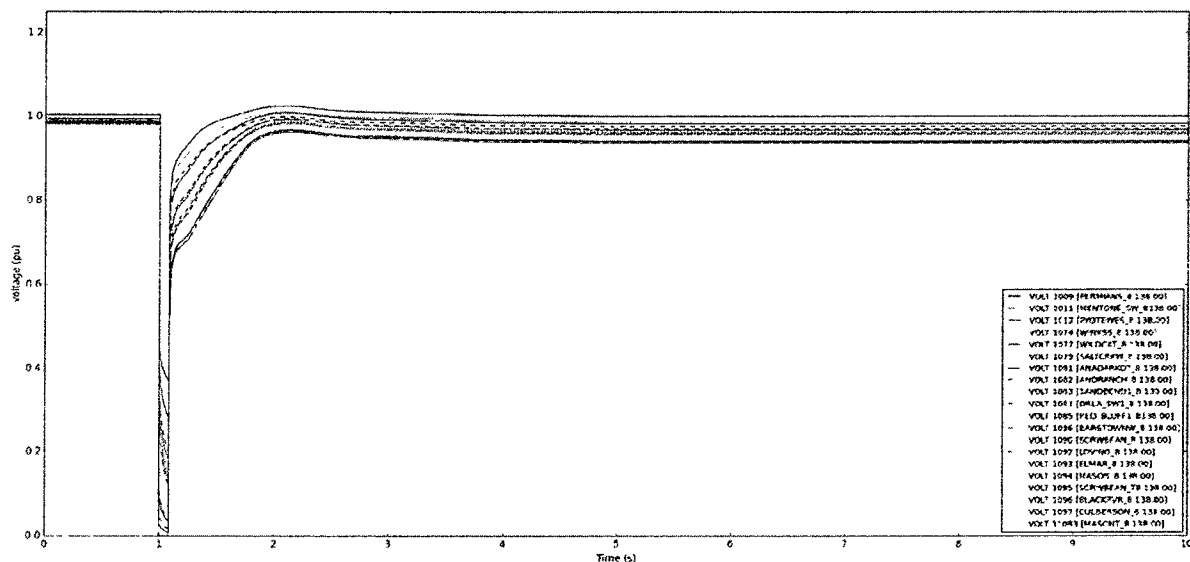


Figure 5 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for Worst Single-Circuit Branch Outage

The majority of the loads on these lines serves oil and gas customers who employ voltage sensitive electric equipment in their operations. For example, many customers are using electric submersible pumps (ESP) as the artificial lift technology for wells. This type of load operates continuously (24 hours/day, 7 days/week) under normal conditions and maintains a high load factor.

With certain double-circuit branch outages, The Wink – Culberson – Yucca Drive Loop is unable to recover to normal levels, which does not meet the ERCOT voltage recovery criteria in the Planning Guide. Figure 6 below shows voltage response under this scenario with the same base case assumptions.

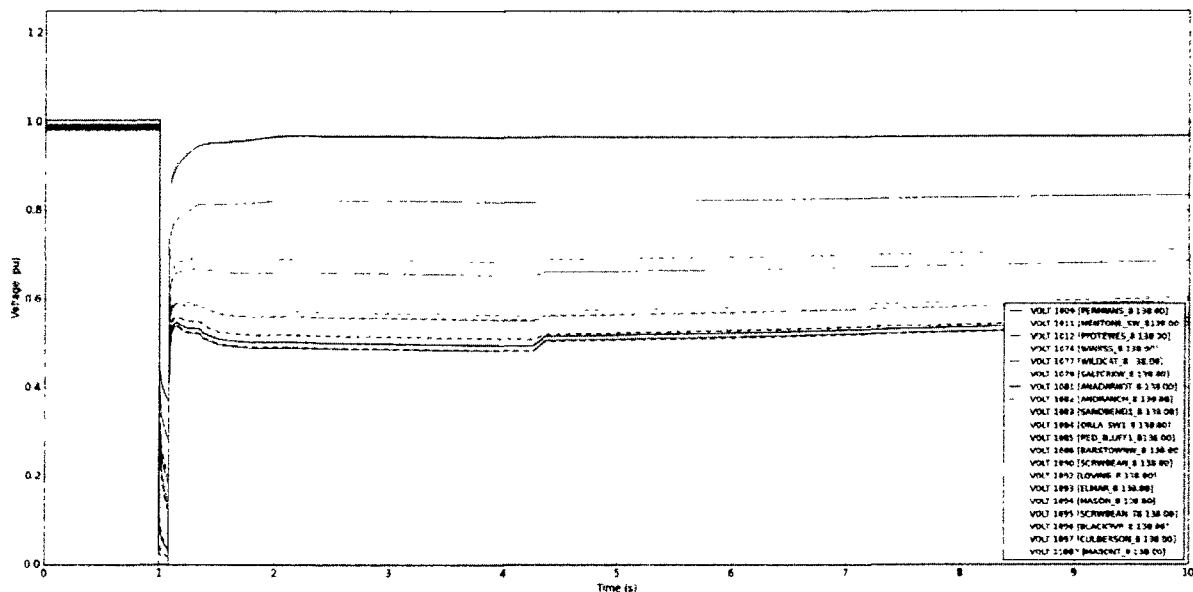


Figure 6 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for Worst Double-Circuit Branch Outage

Certain contingencies beyond NERC requirements can result in consequential load loss or result in a radial 138 kV transmission line exceeding 100 miles in length. Although these contingencies are beyond base planning requirements, the severe consequences merit consideration. The resulting transmission system is skeletal and fragile making discrete switched shunt reactive support not practical because power angles become excessive, and local voltage collapse with loss of load can occur. Figure 7 below shows the simulated dynamic voltage response of The Wink – Culberson – Yucca Drive Loop for one such scenario.

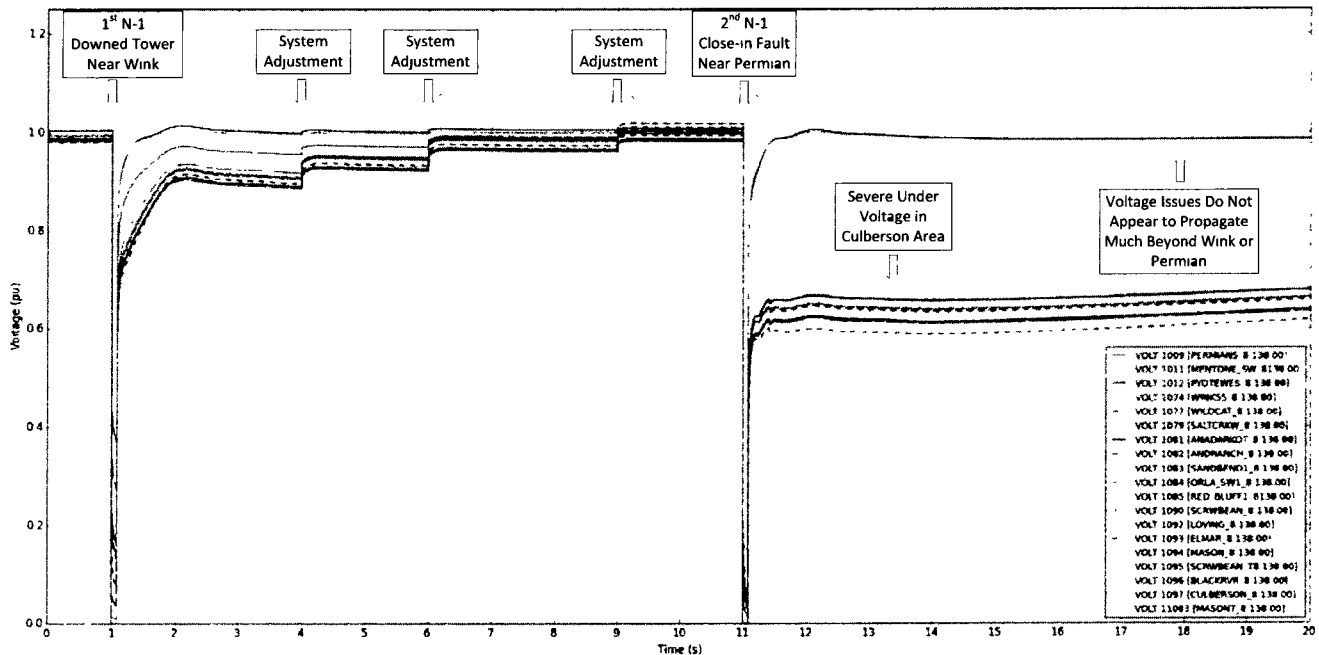


Figure 7 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for N-1-1 contingency (Light Motor Load)

It should be noted that while this simulation is above normal minimum study requirements, it is in line with clearance requests and has significant consequences including load loss exceeding 300 MW. Additionally, the simulation plot above was performed assuming light motor load. If heavy motor load is assumed the dynamic stability simulation fails to converge after the second fault. In fact for The Wink – Culberson – Yucca Drive Loop, heavy motor load may be a more reasonable assumption given the amount of oil and natural gas related customers served from this line. In that scenario, after the system is adjusted, the next contingency results in a local voltage collapse and loss of load that cannot be mitigated by normal operator action. The voltages at Permian Basin and Wink however do stabilize, showing the condition does not propagate to the rest of the system.

The FWTP will strengthen system voltage and provide a strong 345 kV source into The Wink – Culberson – Yucca Drive Loop. This will address the voltage collapse concerns described previously and provide a resilient long-term solution for increasing system strength in the area. Figure 8 and Figure 9 below show the same dynamic simulation with the FWTP modeled. Figure 8 shows the voltage response assuming light motor loading and Figure 9 shows the voltage response assuming heaving motor load. In both cases, the voltage collapse conditions after the worst N-1-1 contingencies are completely mitigated by the 345 kV loop.

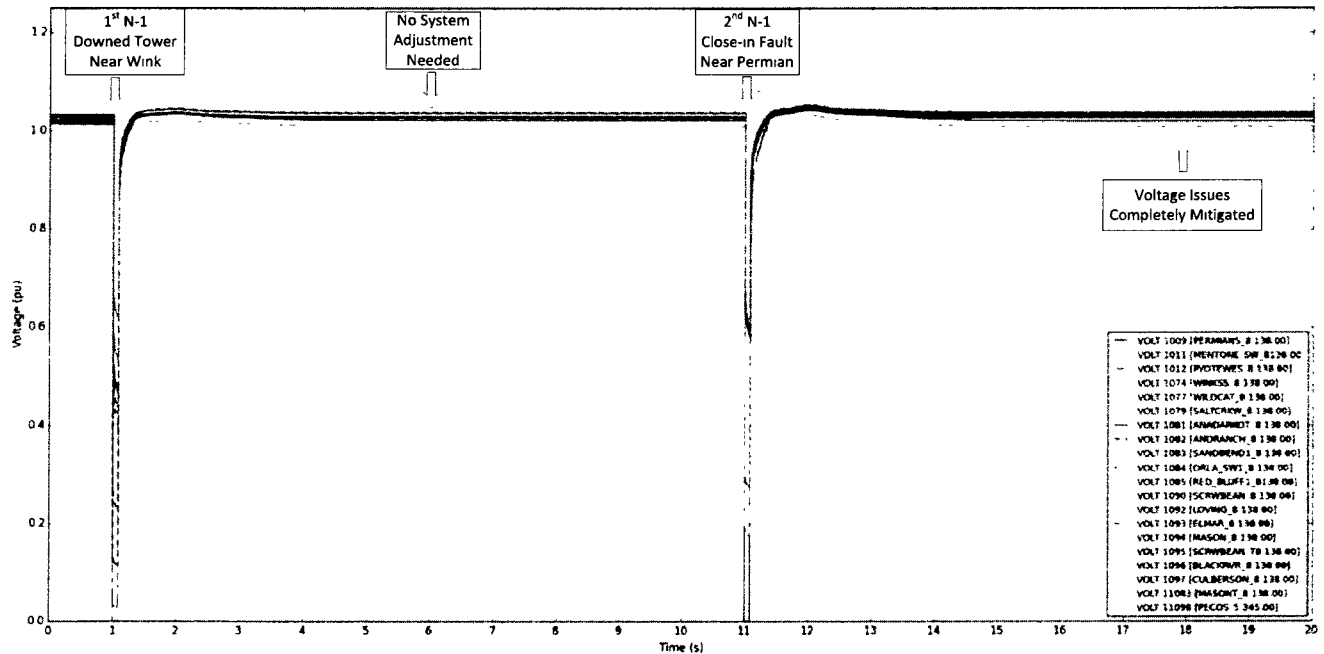


Figure 8 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for N-1-1 contingency (Light Motor Load) – FWTP

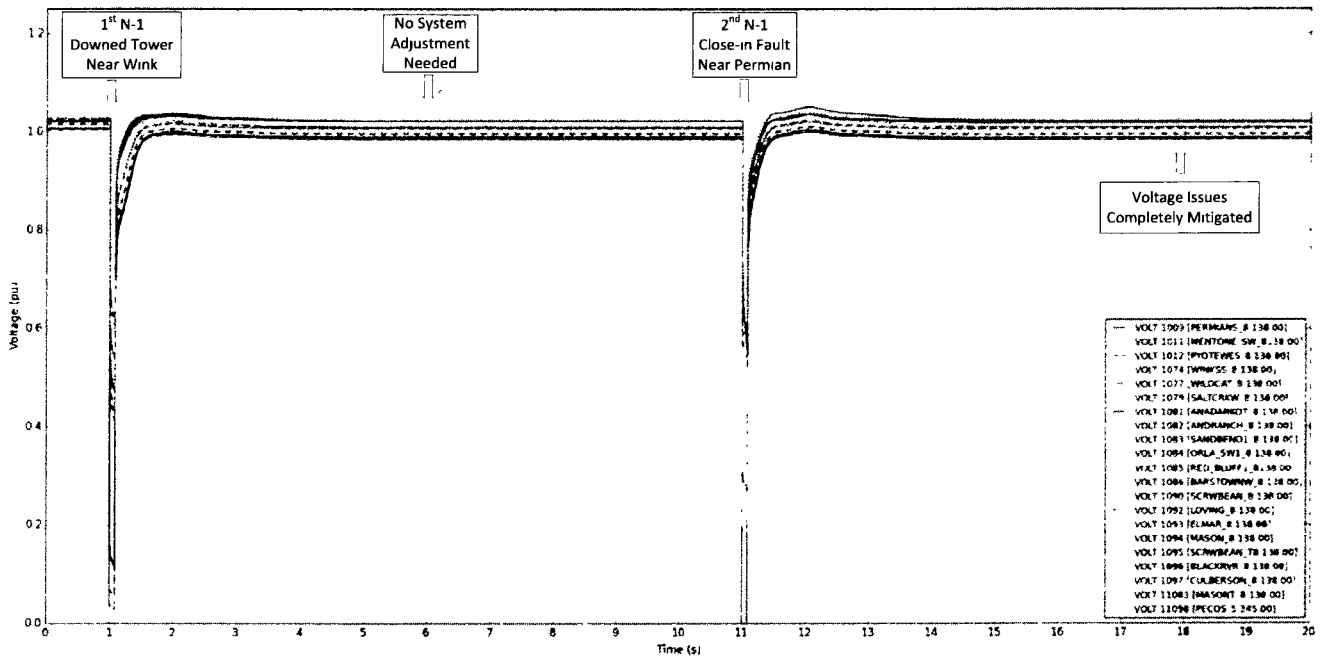


Figure 9 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for N-1-1 contingency (Heavy Motor Load) – FWTP

## ERCOT Studies

ERCOT identified similar planning criteria violations to the Oncor studies in its 2015 Regional Transmission Plan (RTP) and its preliminary 2015 West Texas Study (WTS) results.

The 2015 ERCOT RTP shows similar results to the Oncor studies in the Culberson loop area, with the RTP cases becoming unsolvable under the P1 contingency loss of any one of several single segment circuits on The Wink – Culberson – Yucca Drive Loop. Using the 2015 ERCOT RTP 2018 Summer case posted by ERCOT on April 14, 2015, the same unsolved case conditions can be seen after loss of the Wink – Wildcat 138 kV line section. Using either the 2015 ERCOT RTP 2020 or the 2021 cases, the same unsolved case conditions result after the loss of either the Loving – Anderson Ranch or the Wink – Wildcat 138 kV line sections.

As a result, the need for this project was identified in the 2015 RTP as reliability project 2015 RTP-FW3. A portion of the FWTP for a new 345 kV line to the area from Odessa EHV and Moss was identified as a potential project solution. Currently ERCOT is working on the 2016 RTP and has indicated to Oncor that the preliminary results are showing similar issues in the area.

Similarly, the same conditions were seen in the preliminary results provided to Oncor for the 2015 ERCOT WTS. Using the 2015 ERCOT WTS 2017 Summer Case posted by ERCOT on May 15, 2015, loss of the Wink – Loving 138 kV line section results in The Wink – Culberson – Yucca Drive Loop unable to maintain adequate voltage limits and results in the same unsolved case conditions seen by Oncor studies. The ERCOT WTS 2019 and 2020 cases show similar results under the same contingencies.

## AEP Studies

As part of the Barrilla Junction Area Improvement Project RPG submission, AEP performed numerous steady-state studies assessing the integrity of the transmission system in The Barrilla Junction Area. In these studies, AEP identified additional thermal and voltage violations beyond the direct interconnection facilities of the Barrilla Junction to Yucca Drive 138 kV Line that exceed thermal ratings. These include the 138 kV and 69 kV transmission lines heading south from Barrilla Junction towards the Marfa and Ft. Davis Area, as well as the 138 kV and 69 kV transmission lines heading east from Barrilla Junction/Solstice towards Ft. Stockton Plant and Rio Pecos.

In order to determine the most appropriate system conditions to model for evaluating the reliability of the study area, several scenarios were considered. Combinations of wind, gas and solar generation dispatch were adjusted, simulated, and results compared. Each of the adjusted system conditions used to determine the final scenarios analyzed for the study are detailed in the sections below.

AEP utilized the summer peak power flow cases with High Solar/Low Wind/High Gas (HS/LW/HG), High Solar/High Wind/Low Gas (HS/HW/LG), Low Solar/Low Wind/Low Gas (LS/LW/LG) and Low Solar/Low Wind/High Gas (LS/LW/HG) dispatches.

- In the Low Wind (LW) dispatch, all the area wind generators were dispatched at 20% with the exception of the two Woodward units that were dispatched to 0%.
- In the High Wind (HW) dispatch, all area wind generators including the Woodward units were dispatched at 100% of Pmax.
- In the Low Solar (LS) dispatch, all the solar generators in the study area were dispatched to 0%.
- In the High Solar (HS) dispatch, all solar generators in the study area were dispatched at 100% of Pmax.

- In the Low Gas (LG) dispatch, all the area gas generators were dispatched at 20% with the exception of the Permian Basin gas units that were dispatched at 0%.
- In the High Gas (HG) dispatch, all the area gas generators were dispatched at 100% of Pmax.

The dispatch assumptions associated with the HS/LW/HG, HS/HW/LG, LS/LW/LG and LS/LW/HG scenarios are shown below in Table 3.

	2020 HS/LW/HG	2020 HS/HW/LG	2020 LS/LW/LG	2020 LS/LW/HG
Solar	100%	100%	0%	0%
Wind	20%	100%	20%	20%
Woodward	20%	100%	0%	0%
Gas	100%	20%	100%	100%
Permian	100%	20%	0%	100%

Table 3 – AEP Barrilla Junction Area Study Dispatch Assumptions

As mentioned in the Barrilla Junction Area Improvement Project RPG submittal, AEP studies revealed a number of remaining thermal issues on the two 138 kV transmission paths out of Rio Pecos after the Barrilla Junction Area Improvement Project is implemented. The resulting line loading in The Barrilla Junction Area is shown below in Table 4.

Branch	Rate C (MVA)	Study Case LW/LS/LG %Loading	Study Case HW/HS/LG %Loading	Study Case LW/HS/HG %Loading
Rio Pecos – Woodward Tap 138 kV	170	124	20	18
Rio Pecos – TNMP Woodward Tap 138kV	154	131	113	70
Ft. Stockton Plant 138/69 kV auto transformer	68.8	116	123	67
Ft. Stockton – Tombstone 138 kV	170	99	38	23
Ft. Stockton Plant – TNMP Airport 138 kV	158	106	38	21
Ft. Stockton Plant – Barrilla Jct/Solstice 138 kV	170	124	106	65
Woodward Tap – Tombstone 138 kV	170	124	48	28
Ft. Stockton – Barrilla Junction 69 kV	38	116	127	58
TNMP 16 <sup>th</sup> Street – TNMP Woodward Tap 138 kV	154	131	59	18
TNMP 16 <sup>th</sup> Street – TNMP Airport 138 kV	158	113	44	14

Table 4 – AEP Barrilla Junction Area Study Line Loading

AEP studies show certain scenarios where the amount of generation able to be exported from the Barrilla Junction Area would be limited because of thermal constraints on the transmission system. With the large amount of generation coming online and significant constraints due to the limited exit paths out of the Barrilla Junction Area, generators in the area would likely see curtailments until additional transmission improvements were made in the region.

Additionally, further stability studies have identified voltage stability concerns in the McCamey 138 kV transmission system as a result of the additional generation interconnections at or near the Bakersfield Sw. Sta. The studies

identified certain scenarios where a N-1-1 contingency would limit the amount of generation that can be exported due to voltage stability concerns.

The FWTP will provide an additional export path for generation that would otherwise flow into the McCamey 138 kV system, addressing export limitations due to potential voltage instability. Additionally, the project would create a looped exit path for the approximately 2.2 GW of potential new generation coming online in the Far West Texas transmission system.

### Short Circuit Strength

Short circuit strength in the FWTP's area is also a concern. In the FWTP's area, there are several long lines with significant load that could become radial under P1 contingencies. If a radial line is both long and heavily loaded, it can become difficult for relays to distinguish between fault and load current. Furthermore, low short circuit strength can cause issues for customers, such as inability to start large motors.

Low short circuit strength in an area can cause difficulty in properly protecting the transmission system. Transmission line relays must protect for faults anywhere along the line, even during clearance/outage scenarios. If fault currents in an area are generally low, the outage of a nearby source can significantly reduce the availability of relay settings that reliably trip for any fault condition, while simultaneously avoiding trips for any non-fault condition. Additionally, relay coordination with breakers in surrounding areas may become problematic.

For example, during certain outages in The Wink – Culberson – Yucca Drive Loop, a fault at the remote end of the radial section may result in fault currents as low as 860 Amperes, which is equivalent to 205 MVA of load at nominal voltage. Under these conditions, the maximum load that could be reliably served on this circuit must be below 205 MVA since some margin is required to provide secure protection. This amount is not near the capacity of the line (2,569 Amperes or 614 MVA) and does not meet criteria for system protection requirements. With the FWTP in place, simulations indicate that fault current may increase to 3,300 Amperes for the same scenarios, which is equivalent to 788 MVA of load, exceeding the conductor rating and providing sufficient margin for secure protection.

Figure 10 (next page) shows a color contour map representing the relative short circuit strength in the north part of FWTP's area. The regions colored in red, such as The Wink – Culberson – Yucca Drive Loop in the upper left corner of the diagram, indicate areas with very low short circuit strength. Much of the area is relatively weak, particularly when compared to areas closer to Odessa EHV and conventional generation, shown in the regions in blue. The simulations represented in the maps show the scenario with conventional generation in the FWTP's Area in-service. The situation becomes more dismal if generation in the area is out-of-service as indicated.

The addition of a strong source, such as the injection of a new 345 kV source, into the FWTP's area aids in increasing short circuit strength and stability, particularly when nearby conventional generation is not in-service.

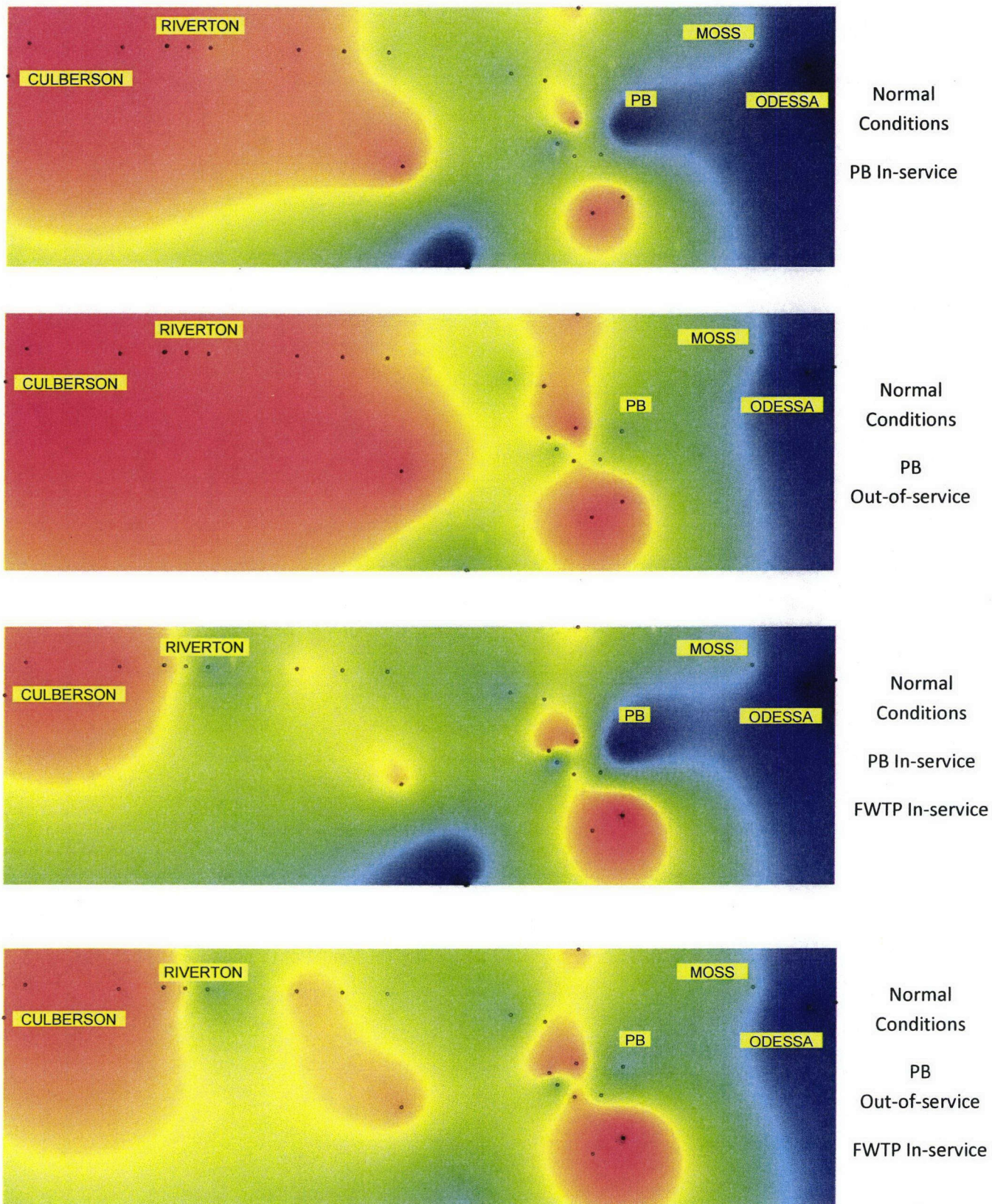


Figure 10 – Relative Short Circuit Strength Color Contour Maps – FWTP

## High Voltage Points-of-Delivery (PODs)

AEP and Oncor continue to receive multiple inquiries from oil and natural gas producers for future high voltage (HV) interconnections along the transmission lines in the Delaware Basin area. In The Wink – Culberson – Yucca Drive Loop, customers with existing HV points-of-delivery (PODs) in the area have projected increases in load. Not included in the projections shown previously in Table 1 are four requests for new customer-owned substations totaling 45 MW. One potential customer has indicated future development plans in the Delaware Basin near the FWTP area that includes electrical requirements that could reach as high as 180 MW total.

The FWTP will help to serve additional load growth by providing extra high-voltage transmission service closer to existing and future customers in the Delaware Basin, where HV PODs can be established. Extending the 345 kV system into these regions of the Delaware Basin will increase system strength and provide voltage support in an area where customers frequently experience low voltage problems and strict motor start limitations.

## TSP Point-of-Interconnections

Challenges in West Texas with regards to rapid changes in generation interconnections, customer service requests, system protection, engineering, constructability, operability, outage/clearances and maintainability have encouraged West Texas TSPs to expand on joint coordination efforts for planning future area needs. As the area continues to see generation and load additions, joint coordination will be needed to ensure a strong and reliable transmission system.

AEP and Oncor have performed joint planning to determine optimal solutions that would benefit all parties. As mentioned previously, AEP and Oncor have immediate needs to rebuild the Yucca Drive – Barrilla Junction 138 kV Line via the Barrilla Junction Area Improvement Project, however these 138 kV upgrades do not resolve all thermal issues on the existing 138 kV lines between Barrilla Junction/Solstice and Rio Pecos. Additionally, Oncor has needs to address the reliability issues in The Wink – Culberson – Yucca Drive Loop.

Texas New Mexico Power (TNMP) has also engaged AEP and Oncor in joint planning discussions in Ward, Winkler, and Reeves counties. TNMP has indicated expected load increases on their transmission system due to large HV customers and sees the need for additional upgrades due to potential thermal and voltage issues post-contingency. TNMP's system in this area is comprised solely of a 69 kV network with radial circuits branching off at multiple points and relies on transmission sources from Oncor's Wink and Permian Basin stations. TNMP has indicated desires for future HV points-of-interconnection with AEP and Oncor in the area, and would greatly benefit from the strong injection source that 345 kV provides.

The FWTP will address planning criteria violations and operational issues for AEP, Oncor and TNMP. Additionally a looped 345 kV line in the area will create additional transmission infrastructure for future points-of-interconnection between other TSPs. Implementation of a 345 kV source provides for a resilient system that all TSPs in the area can benefit from and provides for the beginning of a 345 kV loop around the area, that can be expanded to provide additional lines to the north or east as future needs dictate.

## Operational Flexibility

The lack of operational flexibility when transmission facilities are taken out of service during construction and maintenance is an increasing problem in West Texas. Due to increasing load levels and uncertain availability of wind and other generation in the area, the ability to take facilities out of service for scheduled clearances, maintenance, or testing is limited by voltage and thermal constraints caused by the next contingency. This often leads to congestion and/or unavailability of clearances.

Numerous elements in the FWTP's area are noted as High Impact Transmission Elements (HITEs) by the ERCOT Outage Coordination Improvements Task Force (OCITF). These are transmission elements where outages have contributed to significant congestion and transmission constraints in recent history. Notable elements include the Moss Switch 138 kV Bus, Odessa EHV 138 kV Bus, Midland East – Odessa EHV 345 kV Line, Midland East – Moss 345 kV Line, Moss – Odessa EHV 345 kV Line, and the Odessa EHV 345/138 kV autotransformer #3. With many constraining 345 kV elements in the local area, expansion of the 345 kV system will help strengthen the area to enable clearances and withstand unplanned outages with fewer congestion concerns.

The FWTP will help strengthen the system voltage and increase the operational flexibility in West Texas, allowing utilities to upgrade facilities, perform scheduled maintenance and perform testing of their facilities.

## Region Long Term Upgrade Path

In addition to providing the best technical solution to support planning standard requirements and maintain a reliable system today, the need to optimize improvements to adequately meet future needs must be considered. With limited amounts of transmission infrastructure in areas of far West Texas, new project options to address reliability issues in a fast changing landscape can be limited.

AEP's and Oncor's long range planning analysis considered needs in The Wink – Culberson – Yucca Drive Loop, The Barrilla Junction Area, and Far West Texas in general for future voltage support, transfer capacity, and load serving transformers. Future long-term projects that have been identified include:

- Add 345/138 kV, 600 MVA autotransformer at Sand Lake Sw. Sta.
- Add 345/138 kV, 600 MVA autotransformer at Wolf Sw. Sta.
- Add 345/138 KV, 600 MVA autotransformer at Fort Stockton Plant Sw. Sta.
- Add second 345/138 kV, 600 MVA autotransformer at Moss Sw. Sta.

The Far West Texas Project will have built-in upgrade paths to accommodate future growth needs in the region. This will provide flexibility for future project additions depending on timing of future load or generation increases. Based on increasing load and future interconnections with other TSP's in The Wink – Culberson – Yucca Drive Loop, the Sand Lake 345/138 kV autotransformer can be quickly installed to meet required needs.

In addition to locations where an autotransformer can be installed relatively quickly, a second 345 kV circuit can be installed to provide additional transfer capacity in The Wink – Culberson – Yucca Drive Loop and The Barrilla Junction Area. These upgrades will ensure the proposed solution is a resilient option that can meet future long range needs in Far West Texas.

## Project Description

AEP and Oncor will coordinate respective portions of the project to support design, construction, and other activities. The estimated in-service date is 2021 to 2022. This date may change based on uncertainty in the timing of certification, environmental assessment, land acquisition, critical project status and/or other requirements. Below are individual descriptions of the pieces of this project:

### Odessa EHV – Riverton 345 kV Line (Oncor)

Add a second circuit to the existing 16-mile Moss Sw. Sta. – Odessa EHV 345 kV double-circuit structures. Construct a new approximately 85-mile 345 kV line on double-circuit structures with one circuit in place, between Moss and Riverton Sw. Sta. Install 345 kV circuit breaker(s) at Odessa EHV. Connect the new circuit from Riverton Sw. Sta. and terminate at Odessa EHV to create the new Odessa EHV – Moss – Wolf – Riverton 345 kV Line.

This portion of the project will require the completion of an environmental assessment, alternative route analyses, certification (CCN) proceedings, and the acquisition of new rights-of-way (ROW). The new line should be routed near the future Wolf Sw. Sta. near Permian Basin SES to provide for future facility additions. Oncor is requesting “critical” designation for this line to quickly mitigate the voltage collapse and load loss issue described previously.

### Riverton Switching Station (Oncor)

Expand the Riverton Sw. Sta. to install a 345 kV ring-bus arrangement with one 600 MVA, 345/138 kV autotransformer. Install two 37.5 Mvar (75 Mvar total) shunt reactors on the tertiary of the autotransformer.

### Solstice 345 kV Switching Station (AEP)

Expand the Solstice Sw. Sta. to install a 345 kV ring-bus arrangement with one 675 MVA, 345/138 kV autotransformer.

### Riverton – Solstice 345 kV Line (AEP & Oncor)

Construct a new approximately 66-mile 345 kV line on double-circuit structures with one circuit in place from Riverton Sw. Sta. to Solstice Sw. Sta. Oncor will build half the line from Sand Lake and AEP will build half the line from Solstice.

This portion of the project will require the completion of an environmental assessment, alternative route analyses, certification (CCN) proceedings, and the acquisition of new ROW. The new line should be routed near the future Sand Lake Sw. Sta. for future facilities additions.

### Lynx 345 kV Switching Station (AEP)

Expand the Lynx Sw. Sta. to install a 345 kV ring-bus arrangement with one 675 MVA, 345/138 kV autotransformer.

### Solstice – Lynx 345 kV Line (AEP)

Construct a new approximately 59-mile 345 kV line from Solstice Sw. Sta. to Lynx Sw. Sta. on double-circuit structures with one circuit in place. The new line should be routed near Fort Stockton Plant for future facilities additions.

This portion of the project will require the completion of an environmental assessment, alternative route analyses, certification (CCN) proceedings, and the acquisition of new ROW.

#### **Lynx – Bakersfield 345 kV Line (AEP)**

Construct a new approximately 9-mile 345 kV line from Bakersfield station to the Lynx Sw. Sta. on double-circuit structures with one circuit in place.

This portion of the project will require the completion of an environmental assessment, alternative route analyses, certification (CCN) proceedings, and the acquisition of new ROW.

### **Project Costs**

The total cost of these improvements is estimated at \$423 million. The approximate station and line works costs for AEP and Oncor are shown below.

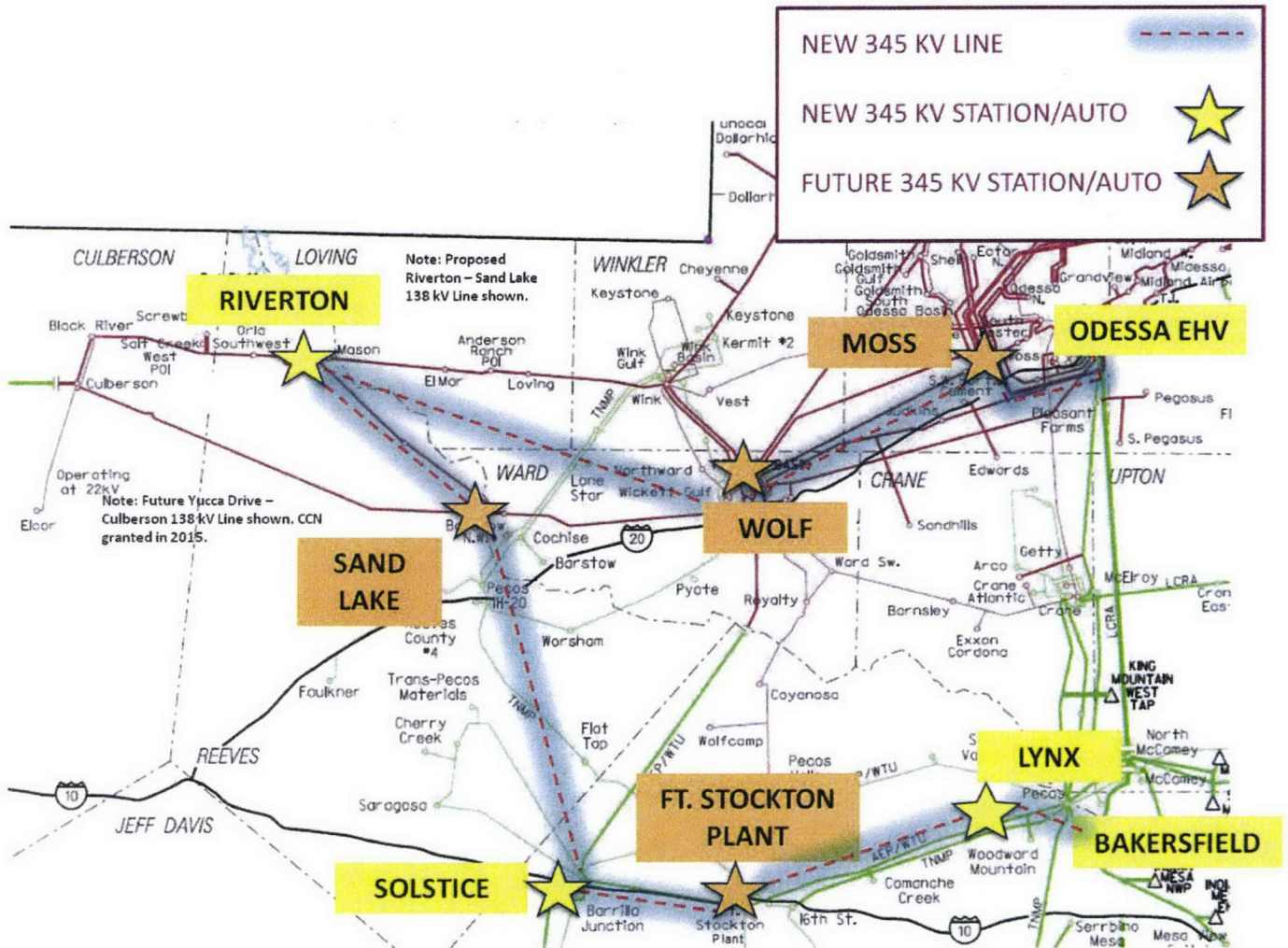
#### **AEP**

- Station: \$43 million
- Line: \$146 million

#### **Oncor**

- Station: \$17 million
- Line: \$217 million

Figure 11 below shows a depiction of the Far West Texas Project overlay using blue highlighting.



## One-line Diagram

Figure 12 below shows a one-line diagram of the area, where the Far West Texas Project components are dashed.

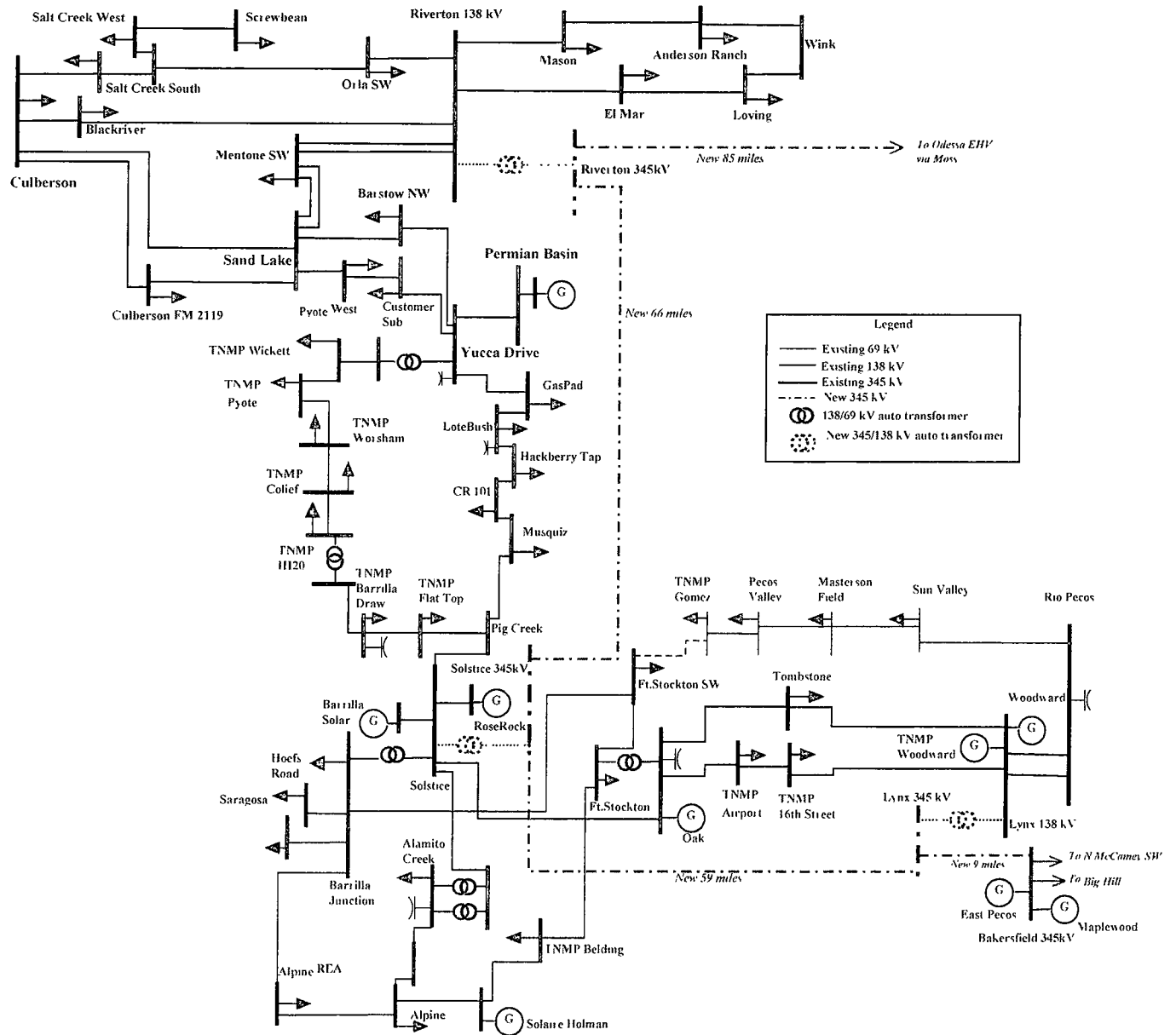


Figure 12- Far West Texas Project One-Line Diagram

## Alternative Projects

Both AEP and Oncor considered various options to resolve the identified reliability issues and provide adequate transmission infrastructure to connect new solar generation and oil and natural gas load. Alternatives to the Far West Texas Project are various combinations of existing 69 kV rebuilds, 138 kV rebuilds, and numerous large dynamic reactive devices. While these alternative projects would address local thermal or voltage issues with varying levels of performance depending on local area generation dispatch and load projections, they have limited improvement on a the larger scale for providing a strong transmission source and a resilient solution to increasing system strength in the area.

Providing single radial 345 kV injection points in the Far West Texas Project's area was considered and would greatly improve system strength, reliability, and address planning criteria violations. However the first contingency loss of any new radial 345 kV line or single 345/138 kV autotransformer would negate the benefit of the single 345 kV source. For example, under certain N-1-1 events, whether through planned or unplanned outages, the same planning criteria issues and subsequent voltage collapse risks in The Wink – Culberson – Yucca Drive Loop would remain. As load increases in the region the ability to take these facilities out for maintenance, testing, or construction clearances will become increasingly difficult. The most effective solution is a 345 kV loop around the area that can be established to provide bi-directional capability of the new 345 kV source.

### Alternative - Dynamic Reactive Device(s), 138 kV, and 69 kV Upgrades

In order to adequately address the short-term criteria violations found by AEP and Oncor, a combination of many 138 kV and 69 kV rebuilds in addition to new dynamic reactive devices, will be needed. These projects are estimated to cost \$480 million and higher.

With no 345 kV source into The Wink – Culberson – Yucca Drive Loop area of the Delaware Basin, Oncor studies indicate that 138 kV network expansion, in combination with large dynamic reactive devices, will be required to support future load growth by helping to provide voltage regulation and enabling adequate power transfer under reasonable operating scenarios.

Oncor dynamic studies have determined that a large synchronous condenser (300 Mvar minimum) would be needed in order to address the previously described issues in The Wink – Culberson – Yucca Drive Loop. The studies show that a Static VAR Compensator (SVC) or a Static Synchronous Compensator (STATCOM) would not converge for a number of simulations, indicating an insufficiency for mitigating the voltage collapse risks.

Figure 13 below shows a comparison of the voltage responses after the worst N-1-1 contingency in The Wink – Culberson – Yucca Drive Loop with a 300 Mvar synchronous condenser modeled at Riverton Sw. Sta. In the simulation, heavy motor load was assumed.

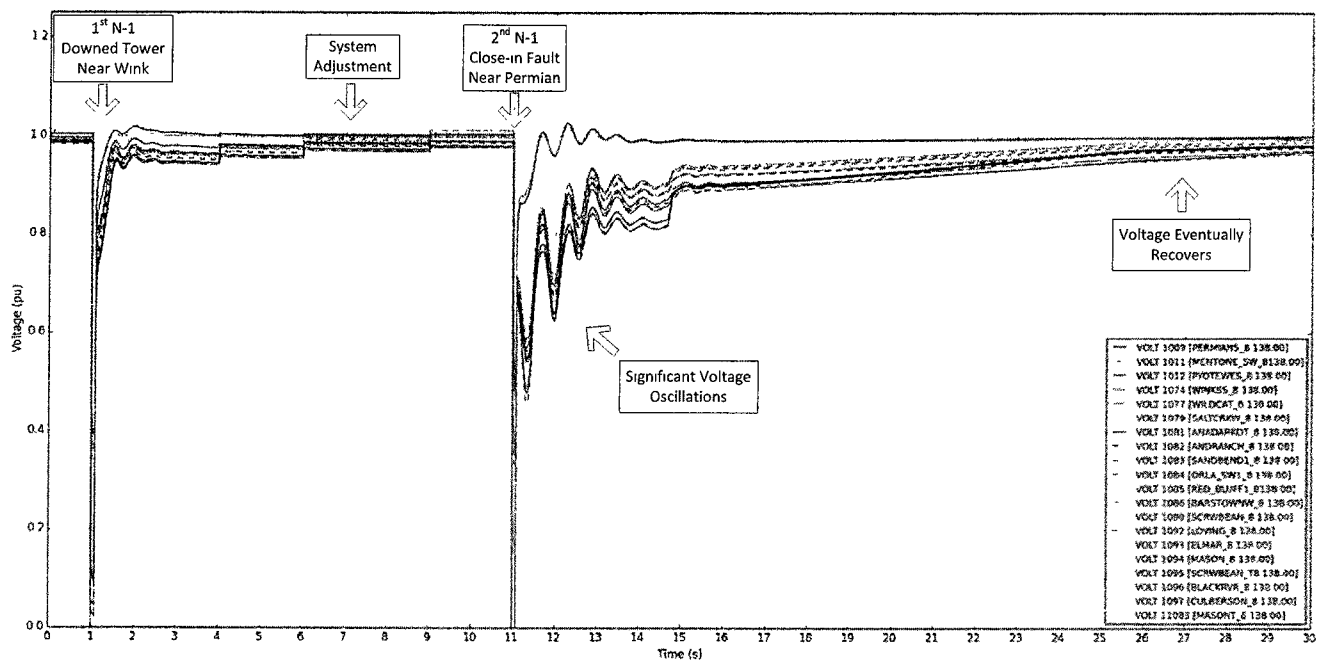


Figure 13 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for N-1-1 contingency (Heavy Motor Load) – 300 Mvar Synchronous Condenser

It should be noted that while the voltage in The Wink – Culberson – Yucca Drive Loop eventually recovers to normal operating levels, there are significant voltage oscillations upon recovery. With potential swings of more than 0.2 PU, electrical equipment including those of customers mentioned previously in this report could be at risk. The required device would likely need to be larger, such as 400 Mvar. Figure 14 below shows the same simulation with a 400 Mvar synchronous condenser modeled.

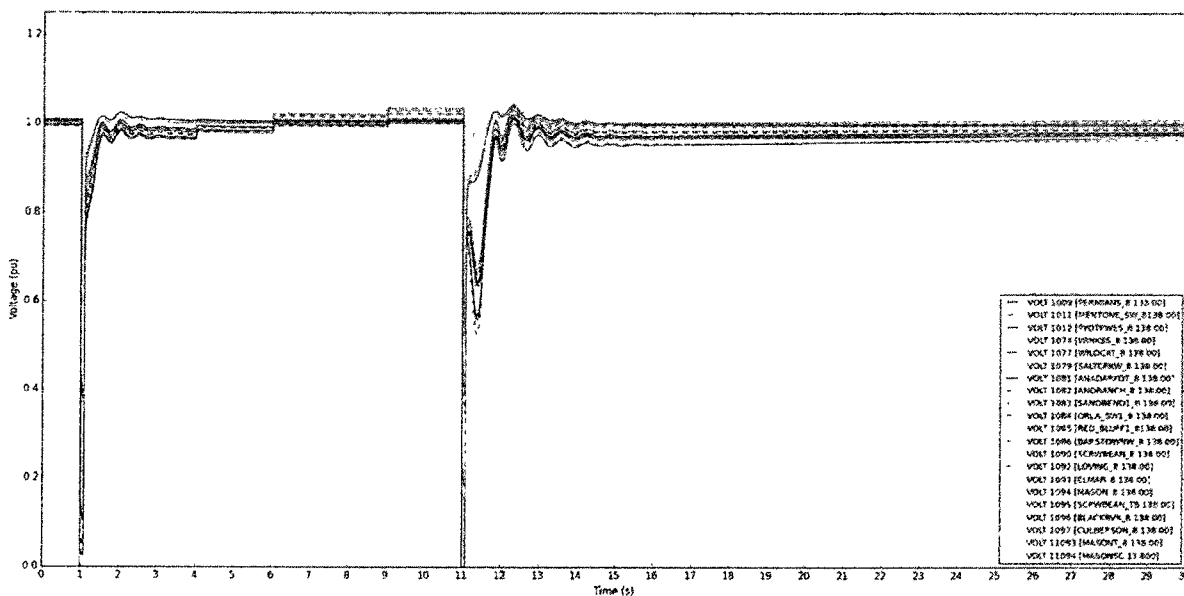


Figure 14– Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for N-1-1 contingency (Heavy Motor Load) – 400 Mvar Synchronous Condenser

Placing such a large, complex device in an extremely remote area also has significant operational and maintenance concerns. The area near Riverton Sw. Sta. is extremely remote, and with limited road access and no nearby population, such a facility would be away from field personnel responding to any planned or unplanned outage, maintenance, or testing. Re-occurring inspections and maintenance will be required which must also be considered in the evaluation of installing such a device. The on-going service costs are not included in the alternative estimate. Additionally, the large size required for a 400 Mvar device will be cumbersome through construction, maintenance, and testing. Two synchronous condensers would be required for redundancy under contingency loss of the first device.

While this alternative addresses the initial planning criteria concerns, this option does not increase system strength and does not provide any strong injection points to the 138 kV system. Additionally, there is no clear upgrade path with these 138 kV and 69 kV alternatives. Future 138 kV projects including new circuits and additional dynamic reactive devices will likely be required as load increases on The Wink – Culberson – Yucca Drive Loop, adding to the future costs of the alternative.

Oncor studies show that if load growth goes beyond current projections in the area, the synchronous condenser would experience angular instability and the simulation solutions would diverge. Figure 15 below shows the voltage response under the worst N-1-1 contingency, if load growth on The Wink – Culberson – Yucca Drive Loop increased above current projections.

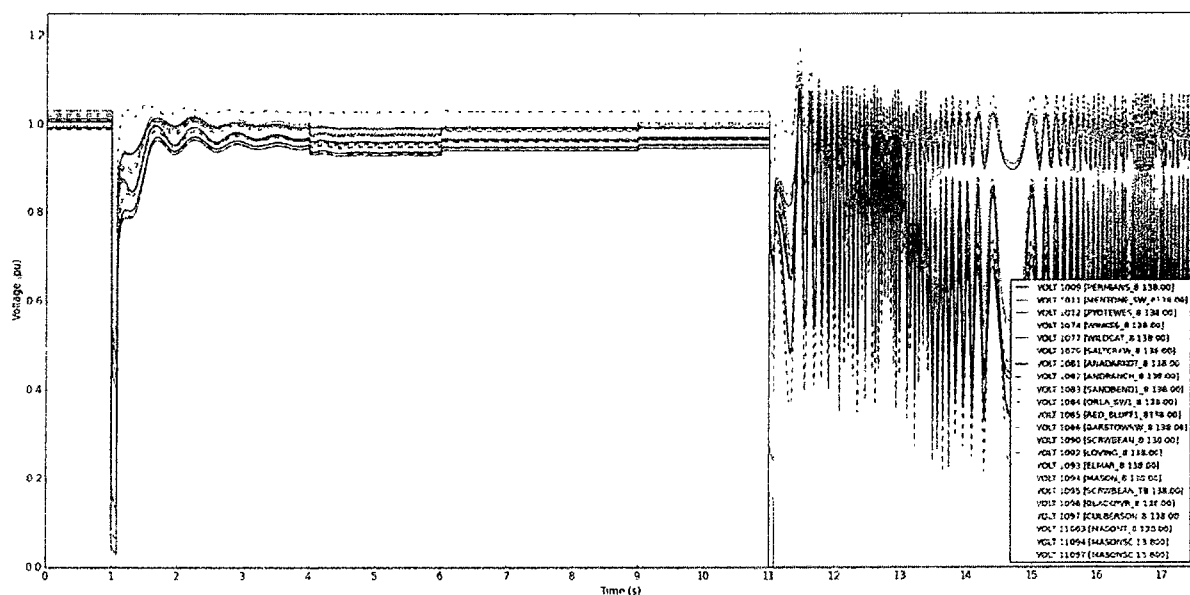


Figure 15 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for N-1-1 contingency – Synchronous Condenser